

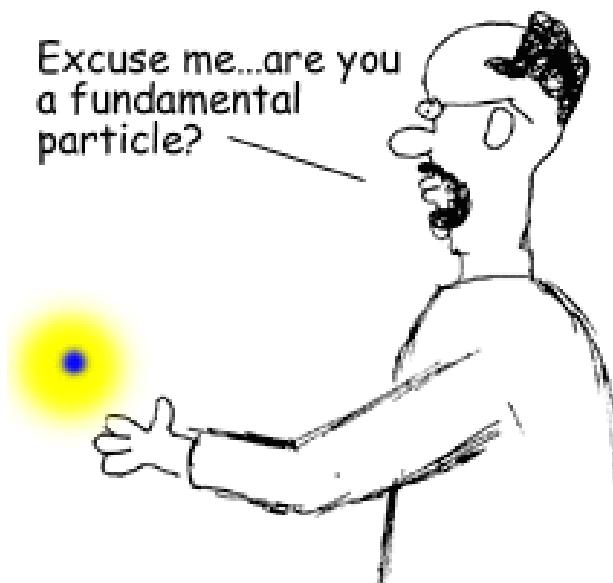


A View of the Top and the Electroweak

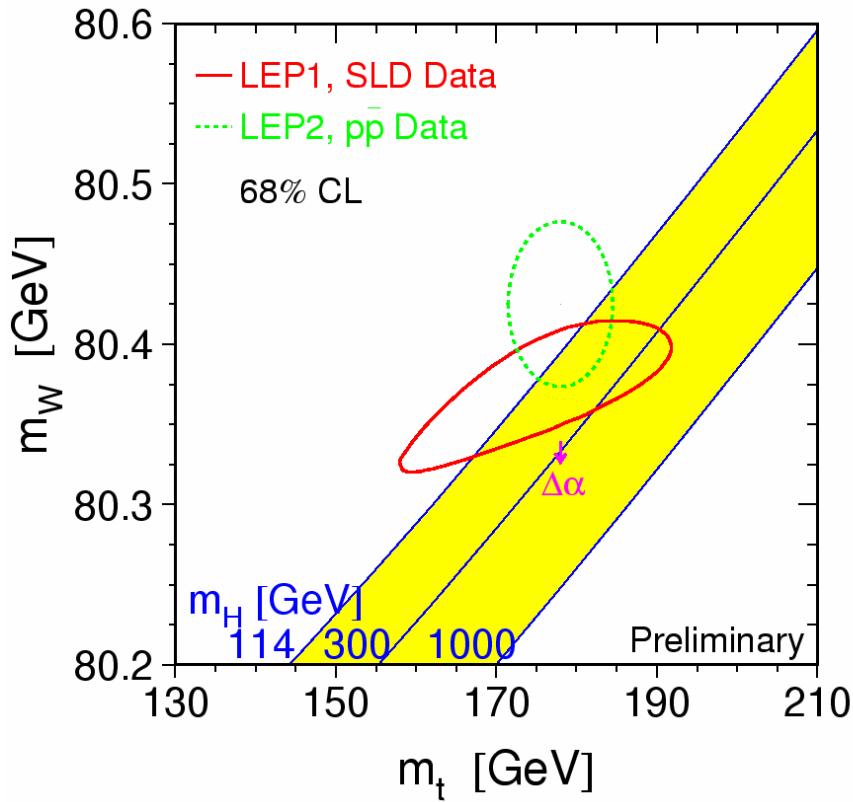


High Energy Physics Seminar
University of Washington
November 16, 2004

*Eva Halkiadakis
University of Rochester
(CDF Collaboration)*



Motivation



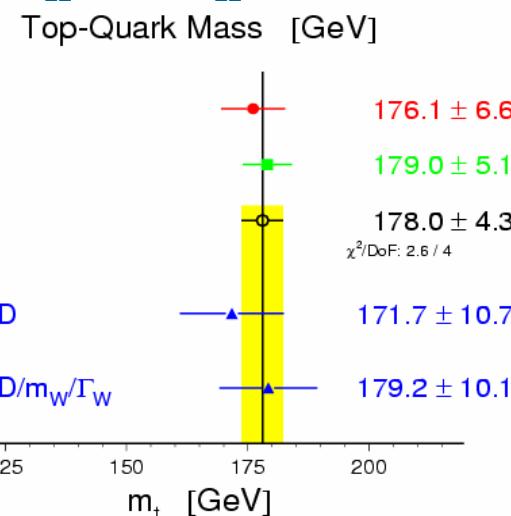
Higgs is “giver” of mass.
It’s mass is tied to m_t and m_W
Example:
5 GeV shift in m_t implies 35% shift in m_H

Direct measurements of top quark and W boson mass

Ø Tests Standard Model predictions

Ø Constrains Standard Model Higgs boson mass

CDF Run II goals (2 fb^{-1}):
 $\delta m_t < 3 \text{ GeV}$ and $\delta m_W \sim 30 \text{ MeV}$
 \rightarrow confine $\delta m_H \sim 2m_H$



Outline

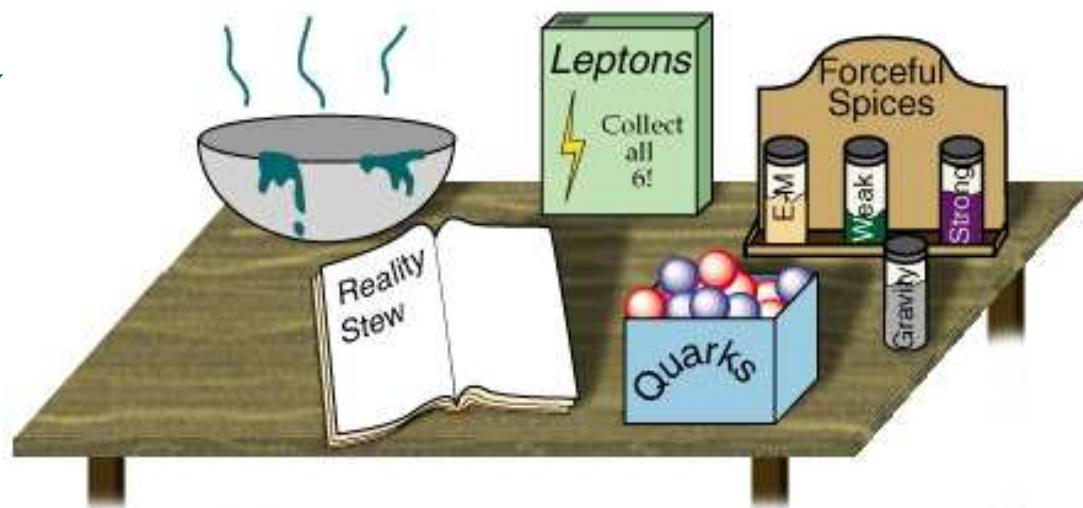
∅ Electroweak Analyses (Reestablish baseline measurements)

- ◆ W/Z production cross sections
- ◆ $R = \sigma(W \rightarrow l\nu)/\sigma(Z^0 \rightarrow l^+l^-)$ (e,μ)
 - extract Γ_W
- ◆ Lepton Universality

∅ Top Physics

- ◆ t-tbar production cross section - dileptons
- ◆ Top quark mass

∅ Summary

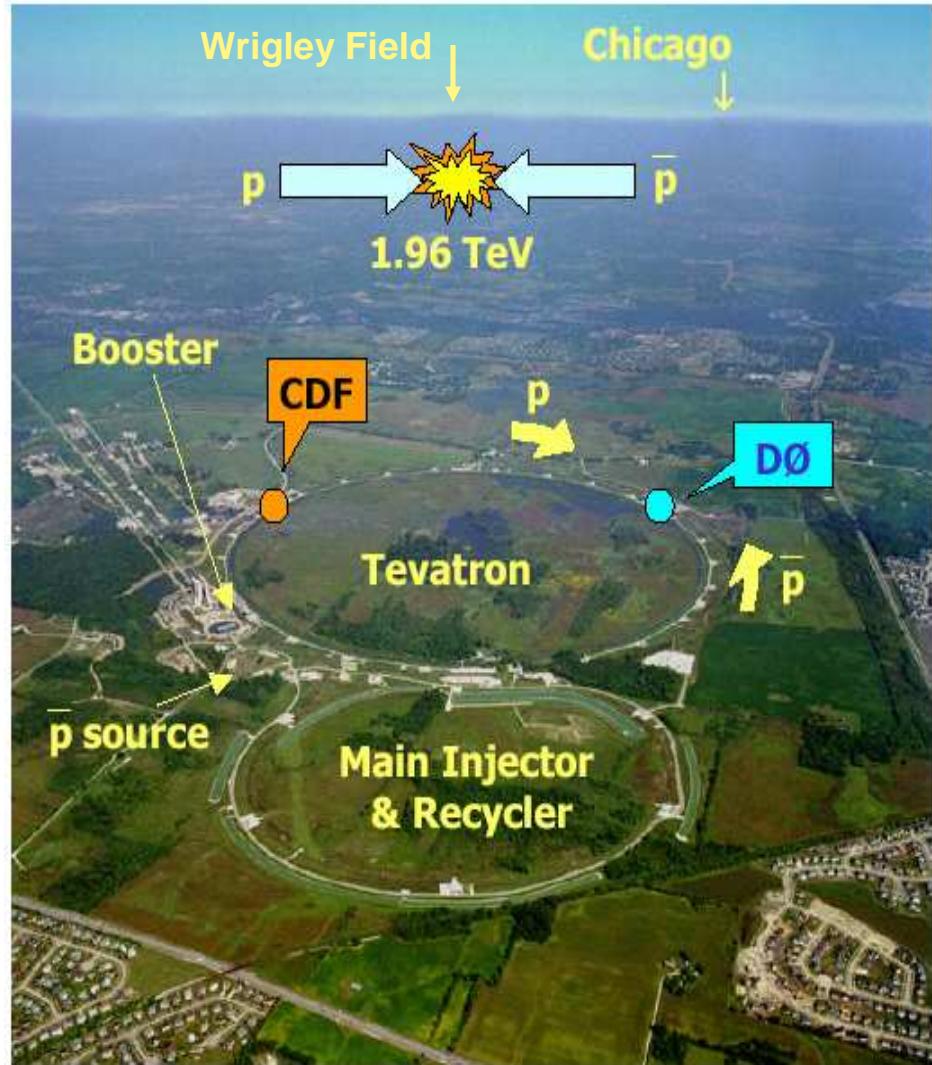


Fermilab Tevatron

- ∅ The Tevatron is a proton-antiproton collider with 980 GeV/beam

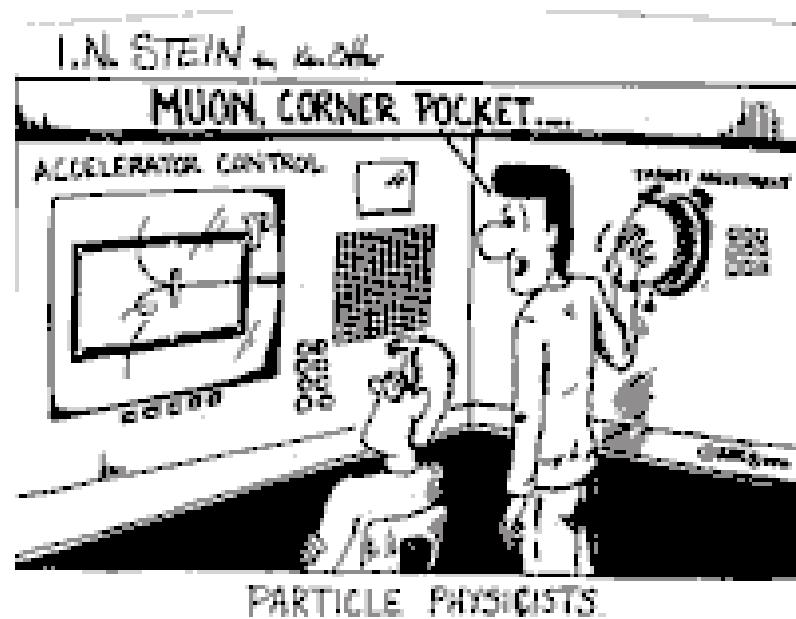
$\sqrt{s} = 1.96 \text{TeV in Run II (1.8TeV Run I)}$

- ∅ 36 x 36 p and pbar bunches à 396 ns between bunch crossings
 - ◆ Increased from 6x6 bunches with 3.5 μs in Run I
- ∅ Increased instantaneous luminosity:
 - ◆ Run II goal $30 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$
 - ◆ Current peak: $10.3 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$
 - ◆ Run I best $2 \times 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$





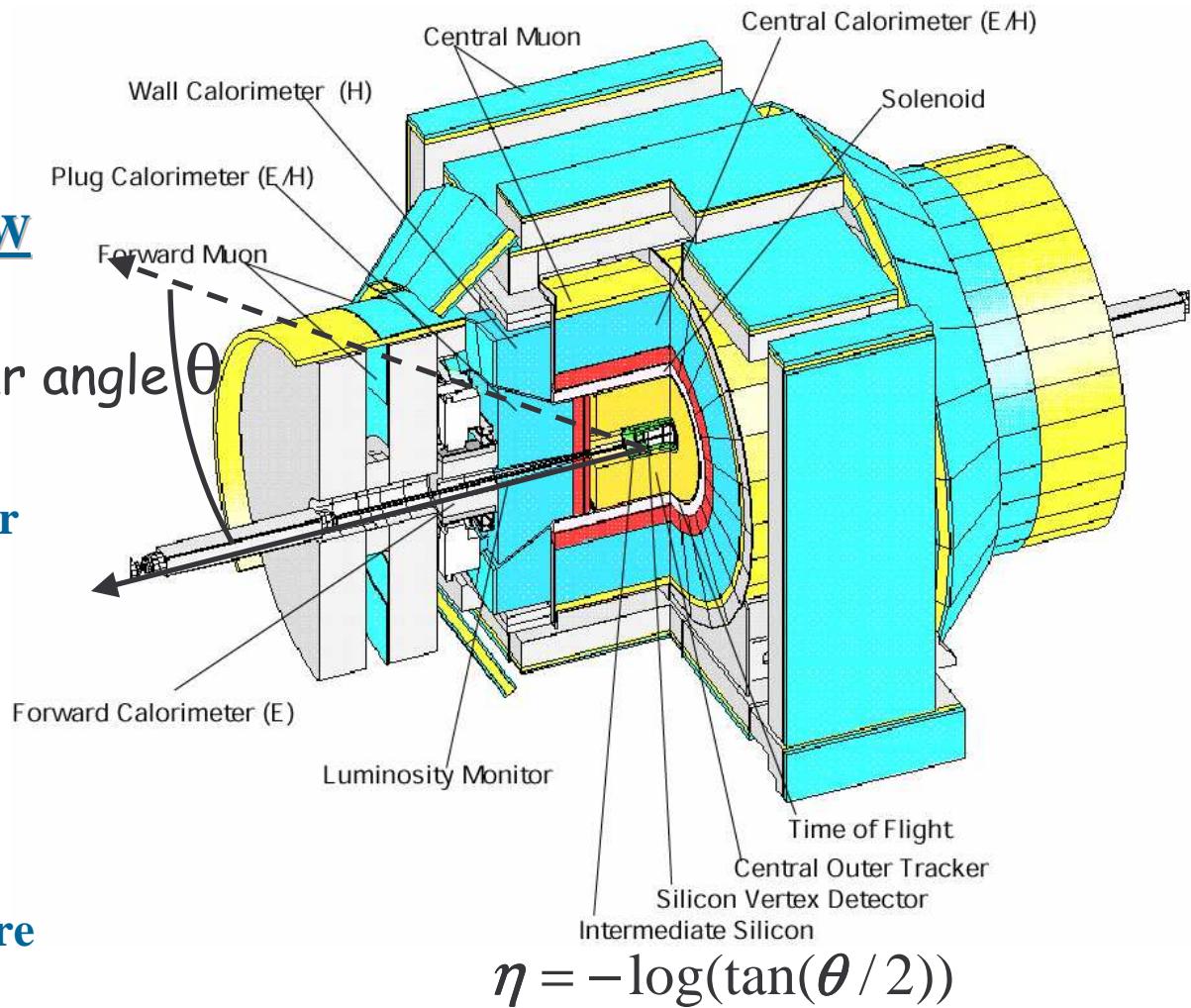
If only it were this easy ...

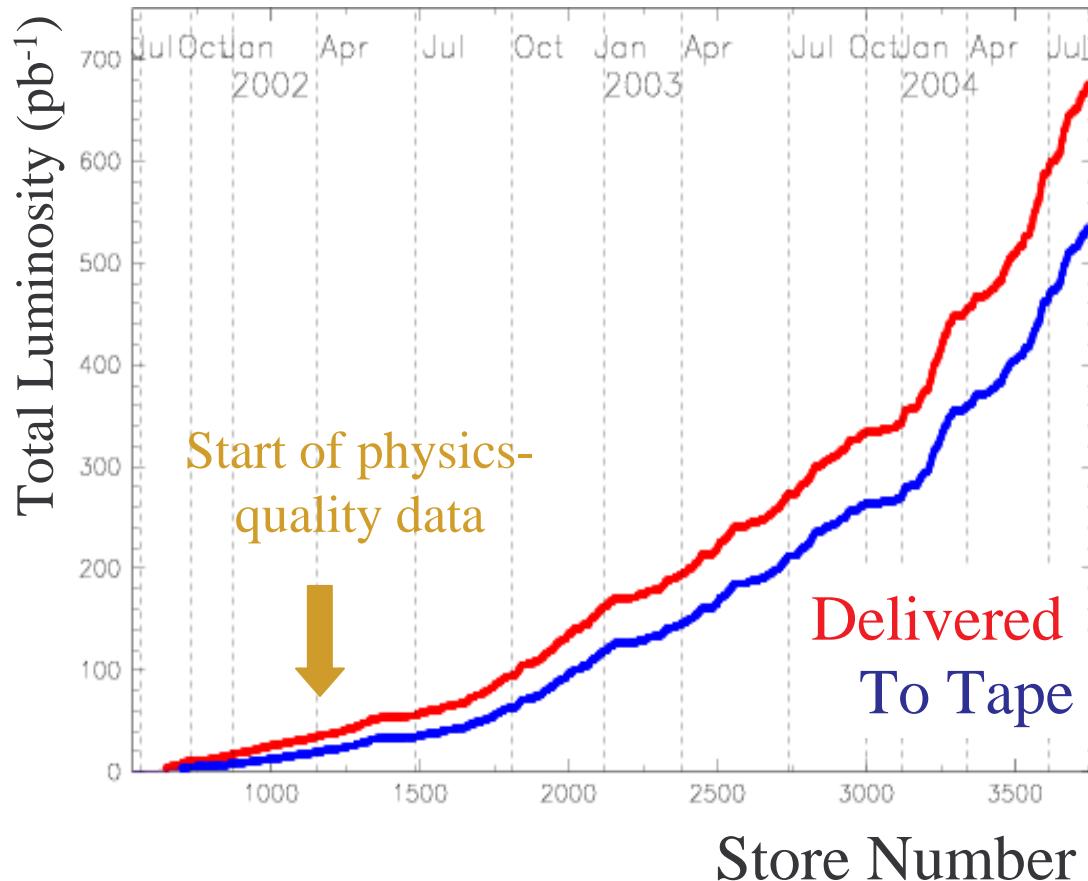


The CDF Run II Detector

What did CDF Keep ?

- ∅ Solenoid
- ∅ Central calorimeter
- ∅ Parts of the muon system
- Most of the detector is NEW
- ∅ Tracking
 - ◆ Silicon Tracker Polar angle θ
(L00, SVX, ISL)
 - ◆ Central Outer Tracker
 - ◆ Time of Flight
- ∅ Endplug Calorimeter
- ∅ Muon systems
- ∅ Front End Electronics
- ∅ Trigger/DAQ (pipelined)
- ∅ Online and Offline software

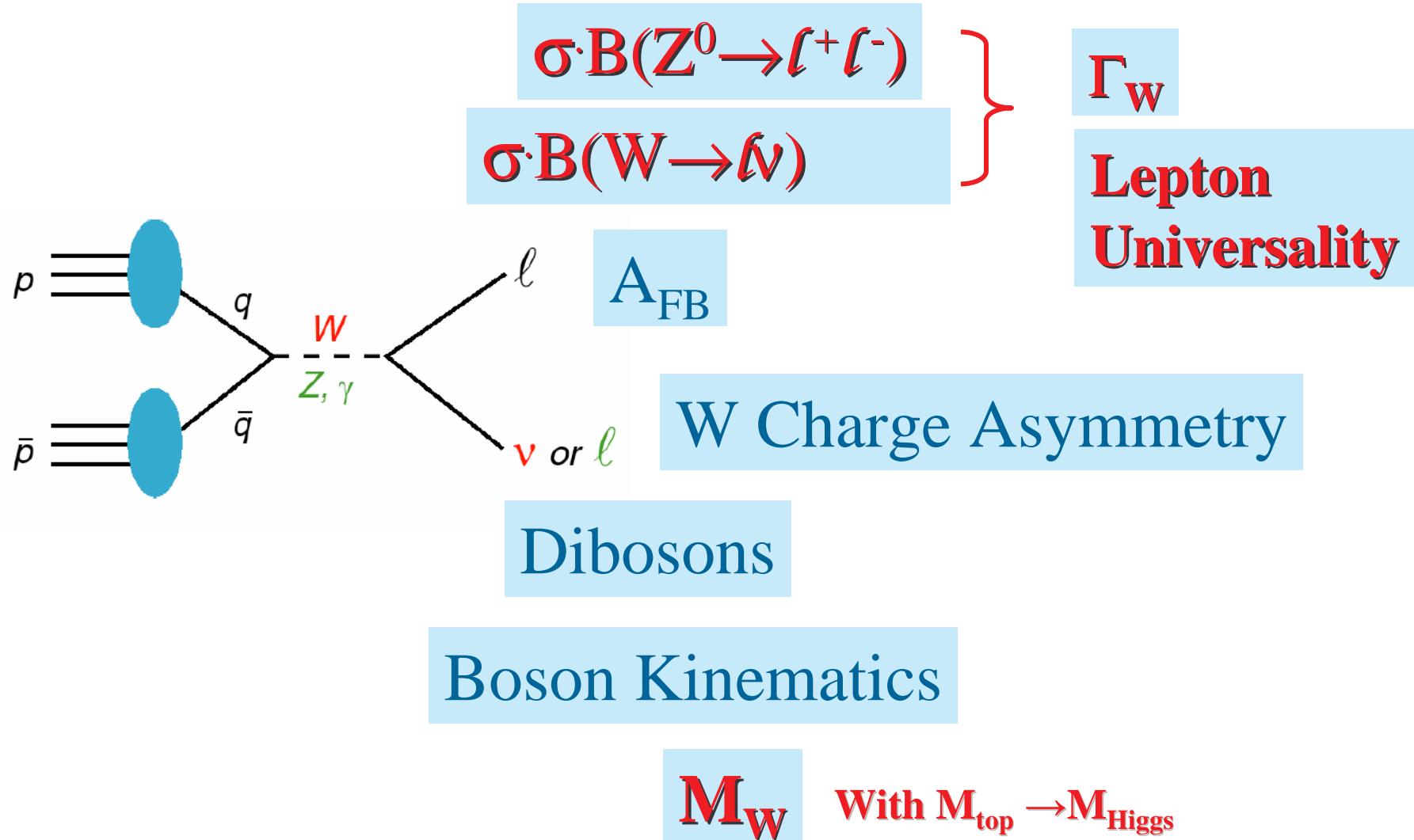


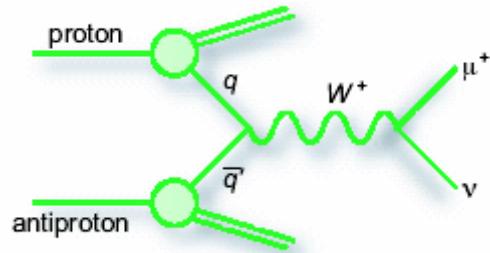


- ∅ ~ 500 pb^{-1} on tape
 - ∅ ~ 360 pb^{-1} with good run requirements
 - ♦ all critical systems, including silicon
 - ∅ Expect 4-9 fb^{-1} by 2009
- Analyses for today:
a range up ~200 pb^{-1}
(March 02 – Sept 03)
- (Run I : 110pb^{-1})



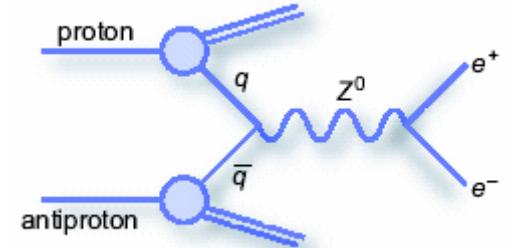
Electroweak Physics Program





Motivation:

- ∅ First measurements of the W and Z cross sections at $s = 1.96 \text{ TeV}$.
- ∅ By measuring $R_{W/Z}$ we can extract the full width of the W , $\Gamma(W)$ (plus other physics quantities).
- ∅ Precision test of the consistency with EWK theory.
- ∅ Tests of perturbative QCD.
- ∅ e, μ comparisons provide tests of lepton universality.





More on W/Z Physics



- ∅ W's and Z's are our *standard candles* – we better get them right!
- ∅ Re-establishing baseline measurements gives us confidence
 - *must walk before we can run!*
- ∅ Benchmark processes for our luminosity measurement.
- ∅ Z's also provide us with useful information about our detector (e.g., EM energy scale and resolution from electrons, p_T scale from muons).

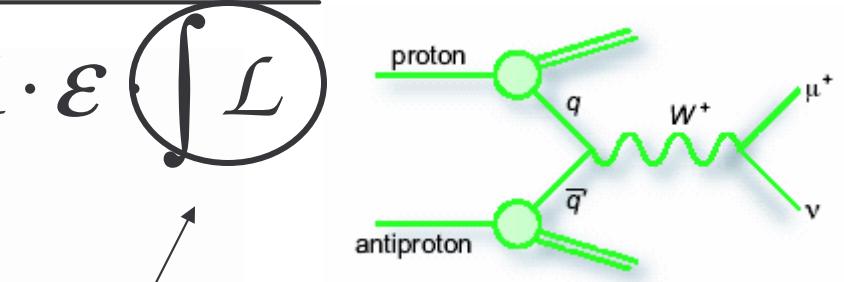


Cross Section

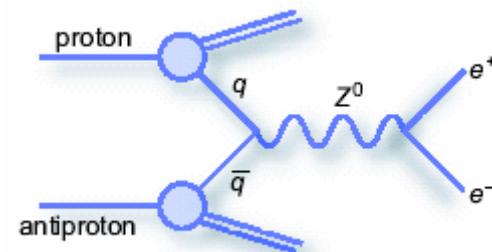
The measurement of a cross section is primarily a “counting experiment”.

$$\sigma \cdot B = \frac{N_{obs} - N_{bkg}}{\mathcal{A} \cdot \epsilon \int \mathcal{L}}$$

- N_{obs} = Number of observed W or Z candidates
- N_{bkg} = Estimated background
- \mathcal{A} = Kinematic + Geometric Acceptance
- ϵ = Total efficiency (vertex, reconstruction, lepton id, trigger, cosmic, etc...)
- $\int \mathcal{L}$ = Total Integrated Luminosity



Uses $\sigma_{inelastic} = 60.7 \pm 2.4 \text{ mb}$ (CDF+E811)



Selecting W 's & Z 's

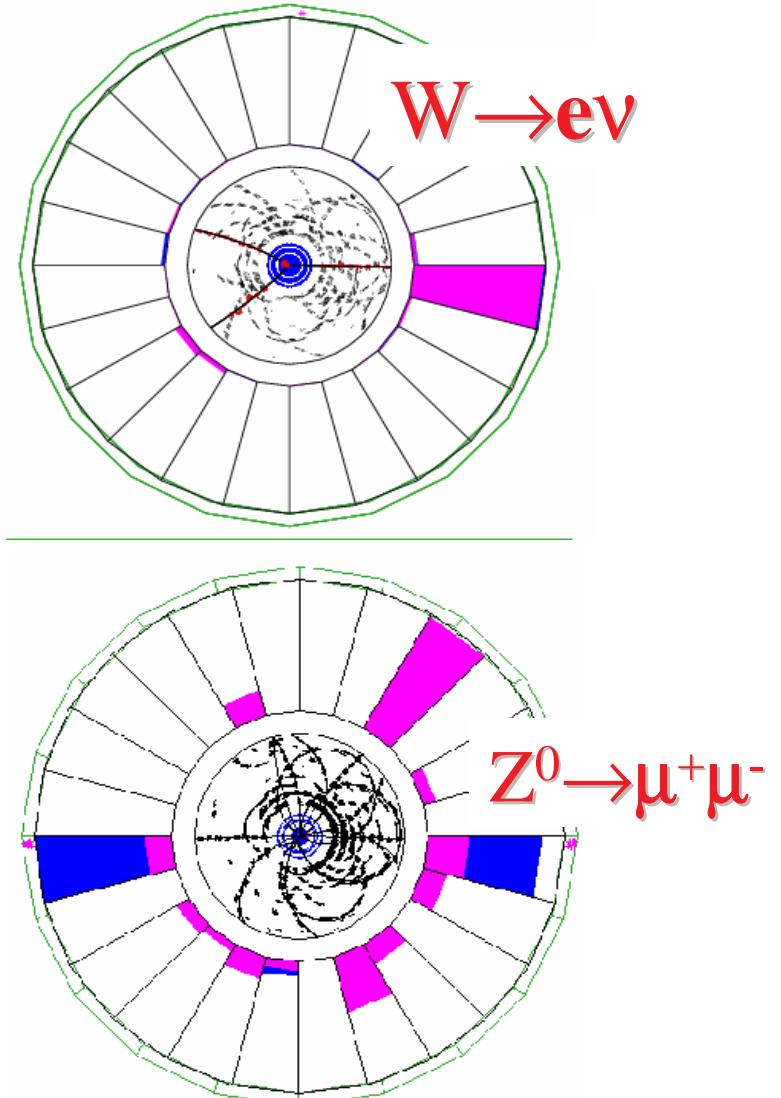
\emptyset W 's:

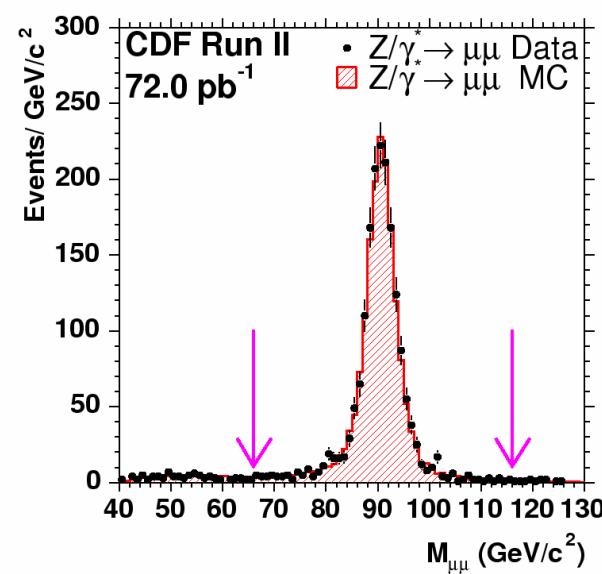
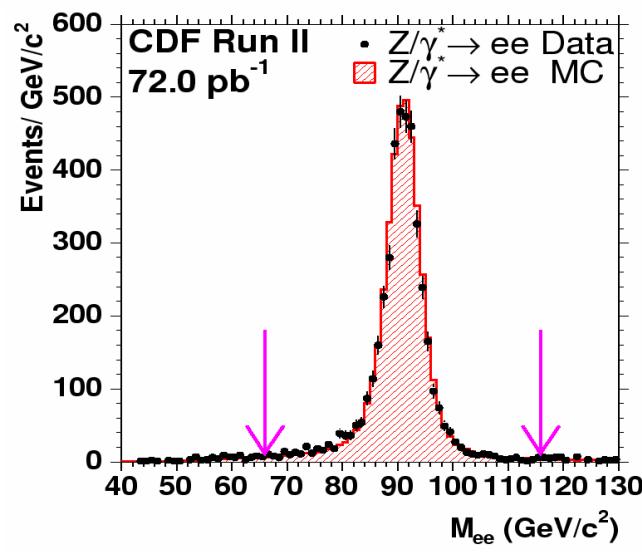
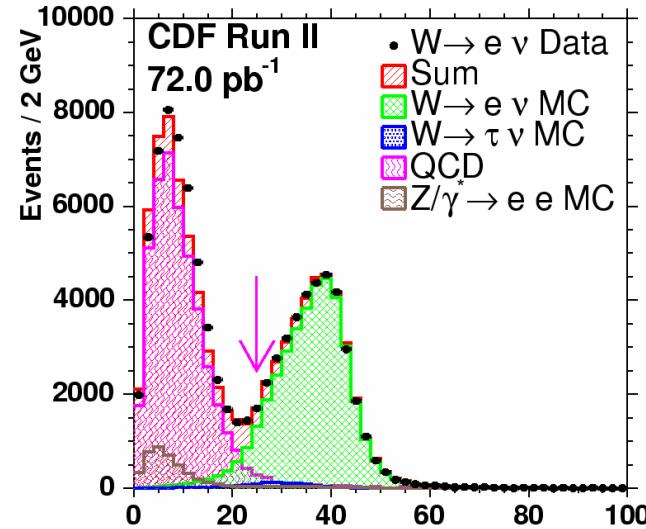
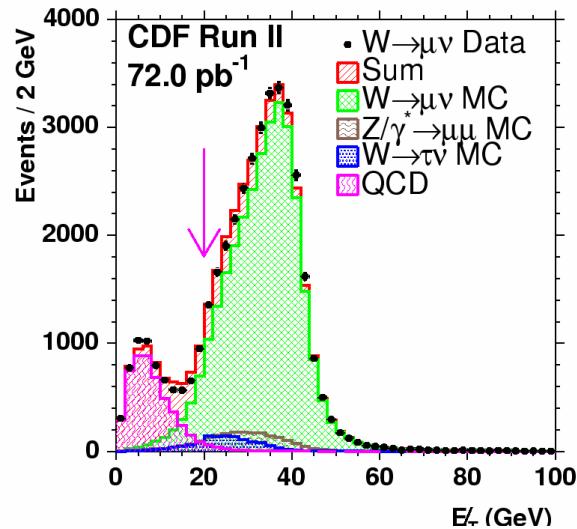
- ◆ One central e or μ
- ◆ Large MET (25 GeV for e's, 20 GeV for μ 's)

\emptyset Z 's:

- ◆ One central e or μ
- ◆ Second *loose* lepton
 - e's: central or forward
 - μ 's: central track
- ◆ In Z mass window ($M_{\ell\ell}$: 66-116 GeV)

	W^\pm	Z^0
Central e, $ \eta <1$	37584	1730
Forward e, $ \eta <2.8$	-	2512
Total e	37584	4242
Central μ , $ \eta <0.6$	21983	1371
Central μ , $0.6< \eta <1$	9739	677
Total μ	31722	1785





Backgrounds

Backgrounds to $W \rightarrow l\nu$:

∅ QCD Background

- ◆ Isolation vs. Met – with *corrections*

∅ EWK Backgrounds

- ◆ $W \rightarrow \tau\nu$ (leptonic τ decay)
- ◆ $Z \rightarrow ll$

∅ Cosmic Ray Background

Backgrounds to $Z \rightarrow ll$:

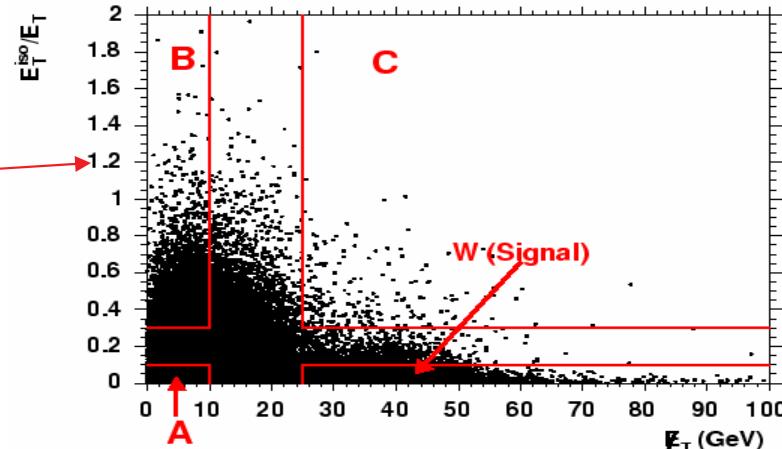
∅ QCD Background

- ◆ Same-sign events/Fake Rates

∅ EWK Backgrounds

- ◆ $W \rightarrow l\nu$
- ◆ $Z \rightarrow \tau\tau$ (leptonic τ decay)

∅ Cosmic Ray Background



category	channel				
	$W \rightarrow e\nu$	$W \rightarrow \mu\nu$	$Z \rightarrow e^+e^-$	$Z \rightarrow \mu^+\mu^-$	
multi-jet	587 ± 299	220 ± 111	41 ± 18	0^{+1}_{-0}	
$Z \rightarrow l^+l^-$	317 ± 14	1739 ± 75	-	-	
$Z \rightarrow \tau^+\tau^-$	negl.	negl.	3.7 ± 0.4	1.5 ± 0.3	
$W \rightarrow \tau\nu$	752 ± 17	998 ± 31	negl.	negl.	
$W \rightarrow l\nu$	-	-	16.8 ± 2.8	negl.	
cosmic rays	negl.	33 ± 23	negl.	12 ± 12	

4.4%	9.4%	1.5%	0.75%
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→ Backgrounds are small and under control.



Efficiencies

The total W or Z efficiency (ε_W , ε_Z) encompasses several different efficiencies:

- Ø Event vertex in luminous region
- Ø Triggering on lepton
- Ø Reconstruction of lepton
- Ø Lepton identification
- Ø Cosmic rejection (μ only)
- Ø Z-rejection (μ only)

Total Z efficiency

	$Z \rightarrow ee$	$Z \rightarrow \mu\mu$
ε_Z	0.713 ± 0.012	0.713 ± 0.015

Total W efficiency

	$W \rightarrow e\nu$	$W \rightarrow \mu\nu$
ε_W	0.749 ± 0.009	0.732 ± 0.013

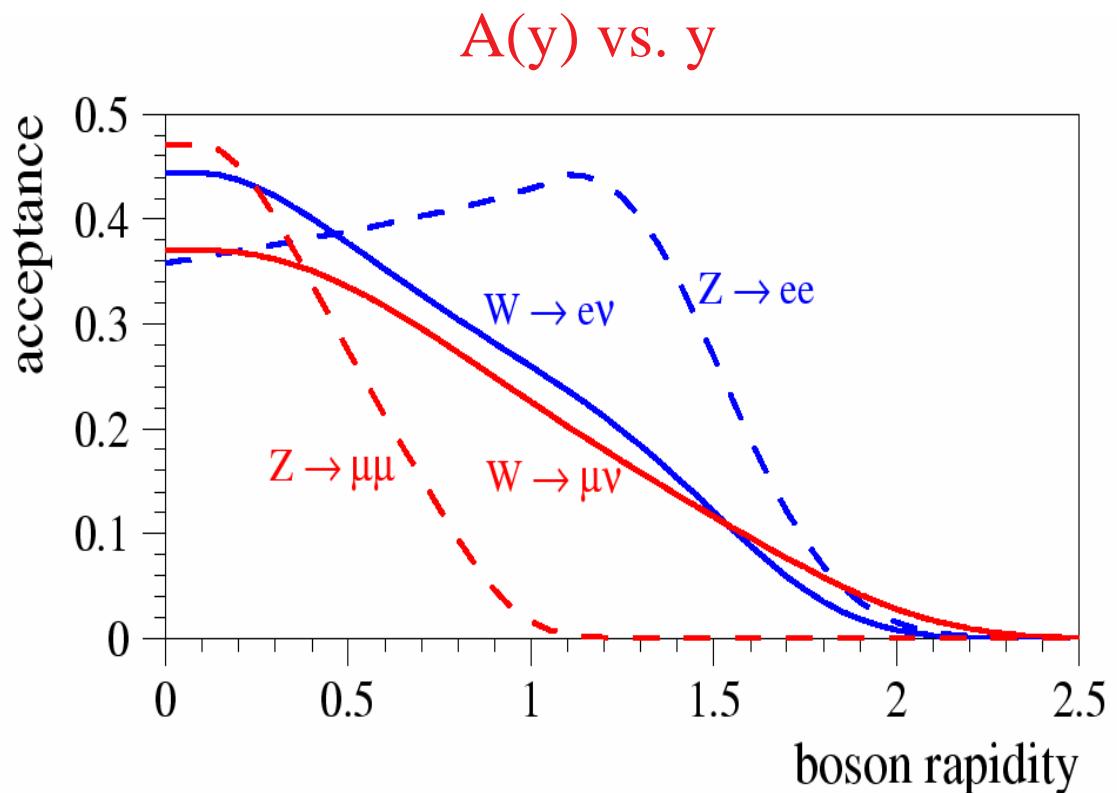
Dominated by data statistics.

Geometric and Kinematic Acceptance

- ∅ Boson rapidity, y , is key quantity
- ∅ Calculate $\mathcal{A}(y)$ from PYTHIA (LO) with detector simulation (GEANT)
- ∅ Convolve with NNLO differential cross-section (C. Anastasiou, et al)

$$A = \frac{\int A(y) \cdot \left(\frac{d\sigma}{dy}\right) \cdot dy}{\int \left(\frac{d\sigma}{dy}\right) \cdot dy}$$

- ∅ Numerical integration is used
- ∅ No stat. component in PDF uncertainties





Acceptance Systematic Uncertainties



∅ Acceptance systematics

- ◆ Dominant is PDFs CTEQ6M (0.7-2.3%)
- ◆ All others small and under control
- ◆ Detector material model also important in electron channels

Uncertainty Category	$\Delta A_{W \rightarrow e\nu}$	$\Delta A_{W \rightarrow \mu\nu}$	$\Delta A_{Z \rightarrow ee}$	$\Delta A_{Z \rightarrow \mu\mu}$
NNLO $d\sigma/dy$ Calculation	0.29 %	0.25 %	0.06 %	0.72 %
PDF Model (positive)	1.16 %	1.13 %	0.69 %	1.72 %
PDF Model (negative)	1.50 %	1.47 %	0.84 %	2.26 %
Boson p_T Model	0.04 %	0.04 %	0.06 %	0.08 %
Recoil Energy Model	0.25 %	0.35 %	0.00 %	0.00 %
Track p_T Scale/Resolution	0.03 %	0.21 %	0.04 %	0.05 %
Cluster E_T Scale/Resolution	0.34 %	0.00 %	0.26 %	0.00 %
Detector Material Model	0.73 %	0.00 %	0.96 %	0.00 %
Monte Carlo Statistics	0.13 %	0.14 %	0.24 %	0.41 %
Total (positive)	1.46 %	1.22 %	1.23 %	1.94 %
Total (negative)	1.75 %	1.57 %	1.26 %	2.44 %



Combining $e + \mu$

We use standard “**BLUE**” method for combining results.
(Best Linear Unbiased Estimation)

Correlated uncertainties:

- PDF uncertainties
- Simulation of boson pT distribution
- p_T scale and resolution
- E_T scale and resolution
- Calibration of hadronic recoil
- Z_{vtx} cut
- Track reconstruction efficiency
- QCD, EWK backgrounds

Uncorrelated uncertainties:

- Trigger efficiency
- Lepton reconstruction efficiency
- Isolation cut
- Cosmic ray rejection
- Z-rejection
- Cosmic ray background



Inclusive W Cross Section



hep/ex 0406078 accepted by PRL!

	e	μ
Number observed events	37584	31722
Estimated Bkg events	1656 ± 300	2990 ± 140
Acceptance	0.2397 ± 0.0039	0.1970 ± 0.0027
Efficiency	0.749 ± 0.009	0.732 ± 0.013
Luminosity	$72.0 \pm 4.3 \text{ pb}^{-1}$	$72.0 \pm 4.3 \text{ pb}^{-1}$

$\sigma_W (\mu)$	$2768 \pm 16 \text{ stat} \pm {}^{67}_{61} \text{ syst} \pm 166 \text{ lum (pb)}$
$\sigma_W (e)$	$2780 \pm 14 \text{ stat} \pm {}^{66}_{57} \text{ syst} \pm 167 \text{ lum (pb)}$
$\sigma_W (e+\mu)$	$2775 \pm 10 \text{ stat} \pm 53 \text{ syst} \pm 166 \text{ lum (pb)}$

~20% improvement in total uncertainty (ignoring lum error) after combining.

NLO @ $\sqrt{s}=1.96 \text{ TeV}$: $2687 \pm 54 \text{ pb}$
(Stirling, van Neerven)

Many systematics can be reduced just by increasing sample size.



Inclusive γ^*/Z Cross Section



hep/ex 0406078 accepted by PRL!

proton antiproton	e	μ
Number observed events	4242	1785
Estimated Bkg events	62 ± 18	13 ± 12
Acceptance	0.3182 ± 0.3182	0.1392 ± 0.0030
Efficiency	0.713 ± 0.012	0.713 ± 0.015
Luminosity	$72.0 \pm 4.3 \text{ pb}^{-1}$	$72.0 \pm 4.3 \text{ pb}^{-1}$

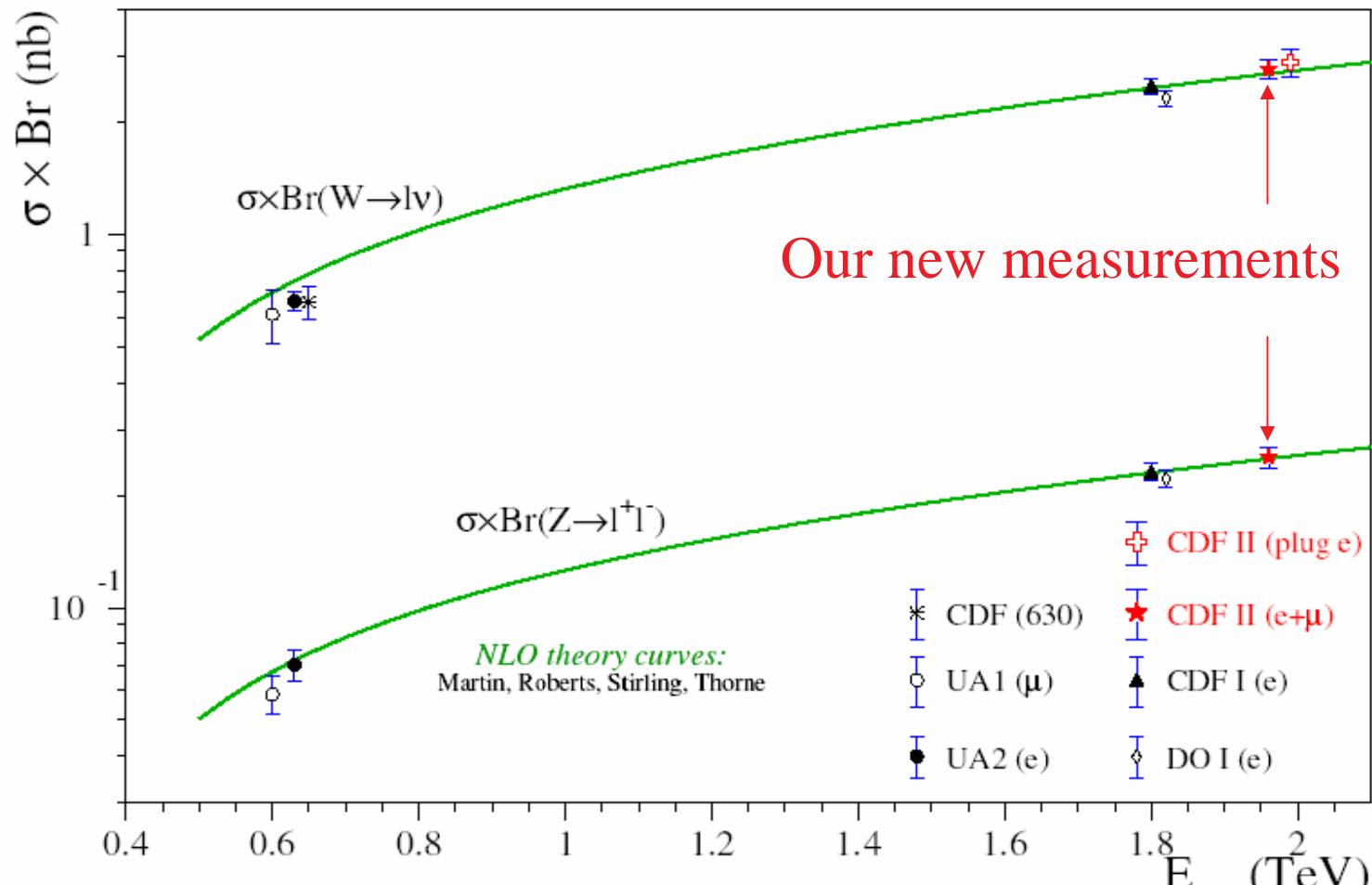
$\sigma_{\gamma^*/Z} (\mu)$	$248.0 \pm 5.9 \text{ stat} \pm {}^{8.0}_{7.2} \text{ syst} \pm 14.9 \text{ lum (pb)}$
$\sigma_{\gamma^*/Z} (e)$	$255.8 \pm 3.9 \text{ stat} \pm {}^{5.6}_{5.4} \text{ syst} \pm 15.4 \text{ lum (pb)}$
$\sigma_{\gamma^*/Z} (e+\mu)$	$253.9 \pm 3.3 \text{ stat} \pm 4.6 \text{ syst} \pm 15.2 \text{ lum (pb)}$

~40% improvement in total uncertainty (ignoring lum error) after combining.

NLO @ $\sqrt{s}=1.96 \text{ TeV}$: $253.1 \pm 5.0 \text{ pb}$
(Stirling, van Neerven)

Many systematics can be reduced just by increasing sample size.

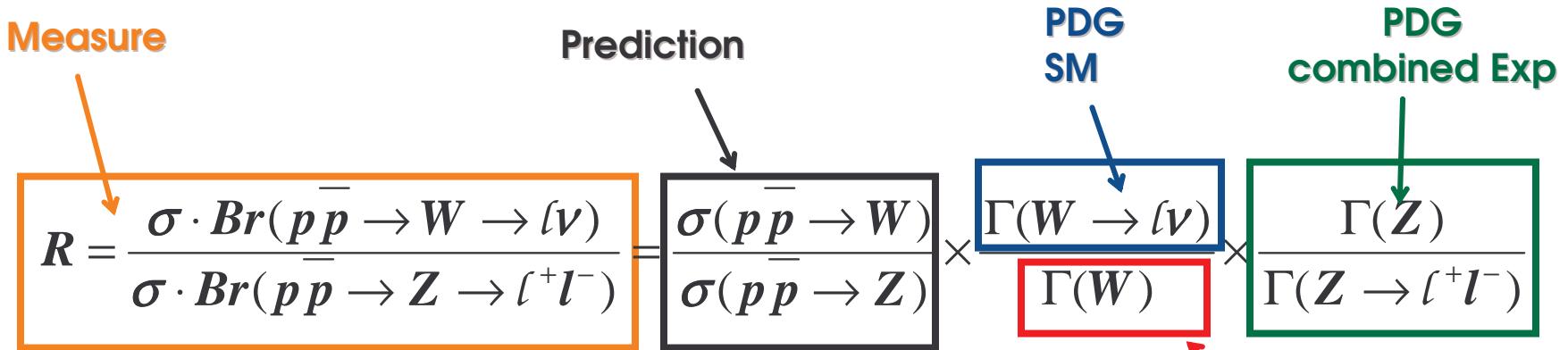
$W \& Z$ Cross Sections vs. E_{CM}



Measurements consistent with SM prediction.



Ratio of Cross Sections



Sensitive to non-SM processes: additional decay modes of W, new high mass resonance decaying to W or Z.

$R(\mu)$	$11.12 \pm 0.27 \text{ stat} \pm 0.18 \text{ syst}$
$R(e)$	$10.82 \pm 0.18 \text{ stat} \pm 0.16 \text{ syst}$
$R(e+\mu)$	$10.92 \pm 0.15 \text{ stat} \pm 0.14 \text{ syst}$

NLO @ $\sqrt{s}=1.96 \text{ TeV}$: 10.69 ± 0.08
(Stirling, van Neerven)

~30% improvement in total uncertainty after combining.

Many systematic uncertainties cancel in the ratio.

hep/ex 0406078 accepted by PRL!



Lepton Universality



$$U \equiv \frac{\sigma \times Br(W \rightarrow \mu\nu)}{\sigma \times Br(W \rightarrow e\nu)} = \frac{\Gamma_W(\mu\nu)}{\Gamma_W(e\nu)} = \frac{g^2_\mu}{g^2_e}$$

- ∅ Stringent tests of universality for Z decays established by LEP experiments.
- ∅ We can use our cross section measurements to test lepton universality for W decays.

$$\frac{g_\mu}{g_e} = 0.998 \pm 0.012$$

No sign of lepton non-universality – ok to combine our e and μ results.

SM value: 1

World Average: 0.993 ± 0.013

Many systematic uncertainties cancel in the ratio.

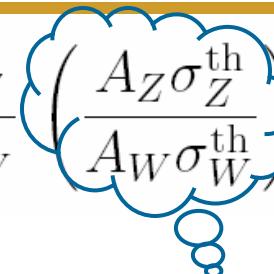
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Summary of Extracted Quantities



$$Br(W \rightarrow \ell\nu) = \frac{N_W(1 - b_W)}{N_Z(1 - b_Z)} \frac{\epsilon_Z}{\epsilon_W} \left(\frac{A_Z \sigma_Z^{\text{th}}}{A_W \sigma_W^{\text{th}}} \right) Br(Z \rightarrow \ell^+ \ell^-)$$



Correlations between σ_Z^{th} & σ_W^{th} , and A_Z & A_W . Careful with PDF uncert.

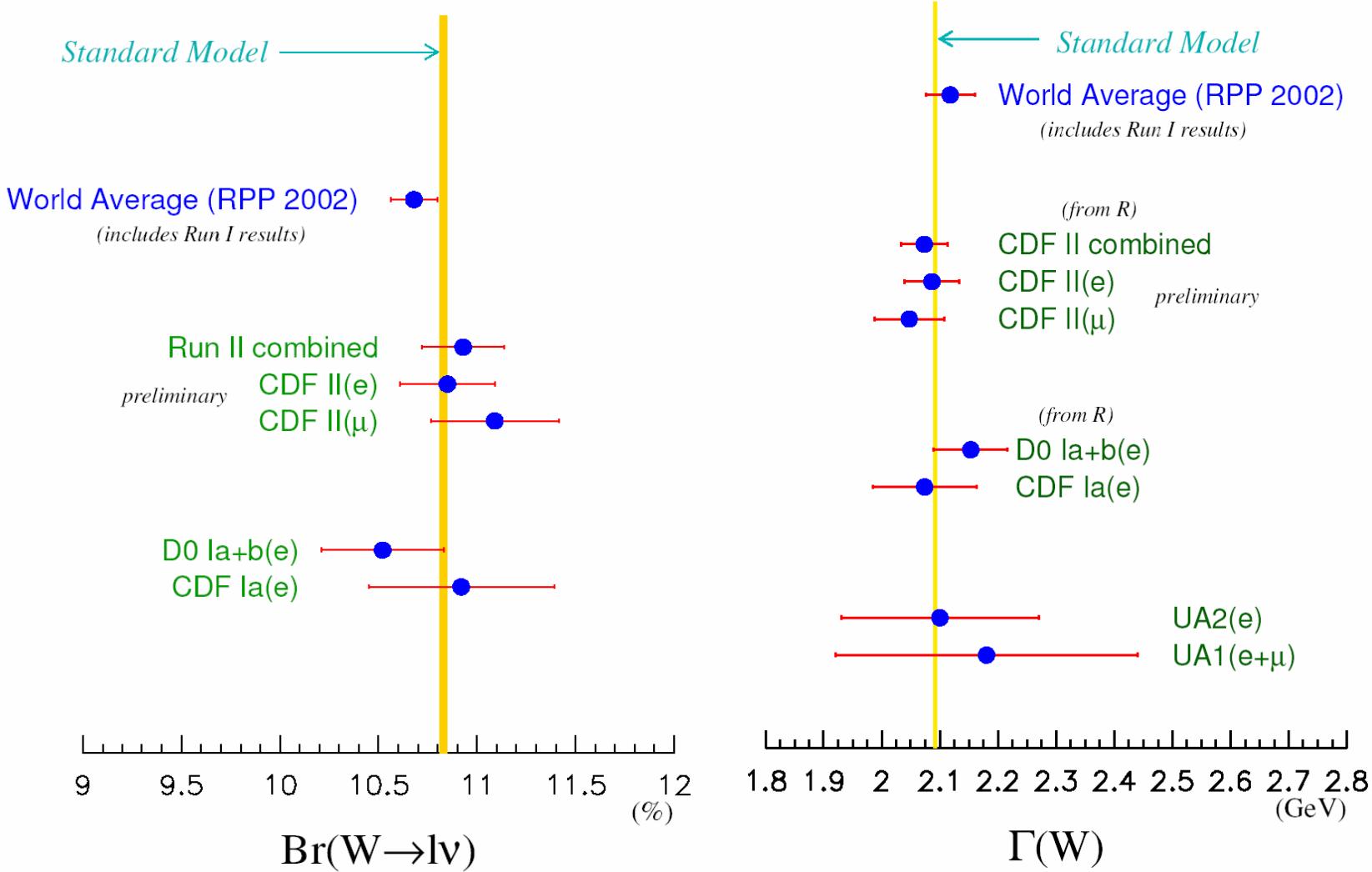
$$\Gamma_W = 3\Gamma_W^0 + 3 \left(1 + \frac{\alpha_s}{\pi} + 1.409 \left(\frac{\alpha_s}{\pi} \right)^2 - 12.77 \left(\frac{\alpha_s}{\pi} \right)^3 \right) \sum_{[\text{no top}]} |V_{qq'}|^2 \Gamma_W^0$$

Total width depends on EWK parameters and first two rows of CKM matrix element. V_{CS} has largest uncertainty \rightarrow use Γ_W measurement to constrain it.

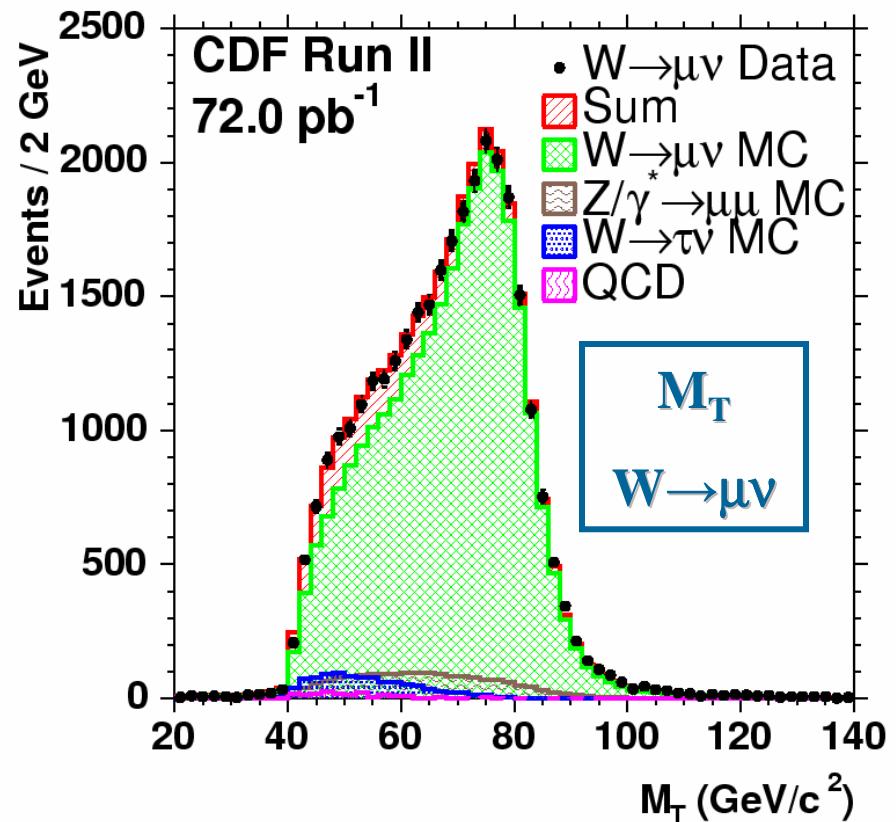
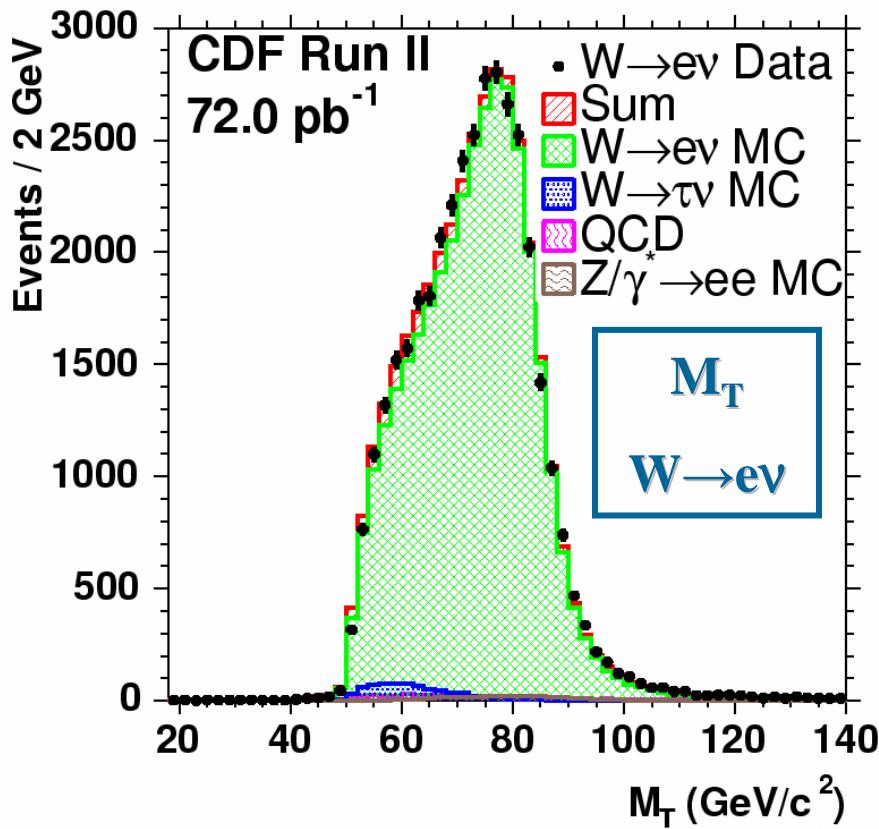
quantity	our measurement	world average	SM value
$Br(W \rightarrow \ell\nu)$	0.1089 ± 0.0022	0.1068 ± 0.0012	0.1082 ± 0.0002
Γ_W (using $Br(Z \rightarrow \ell^+ \ell^-)$) (MeV)	2078.8 ± 41.4	2118 ± 42	2092.1 ± 2.5
M_W (GeV)	80.26 ± 0.52	80.423 ± 0.039	80.391 ± 0.019
Γ_W/Γ_Z	0.833 ± 0.017	0.849 ± 0.017	0.838 ± 0.001
V_{cs}	0.967 ± 0.030	0.996 ± 0.013	N/A
$g_{W\mu}/g_{We}$	0.998 ± 0.012	0.993 ± 0.013	1

hep/ex 0406078 accepted by PRL!

Summary of Indirect Measurements



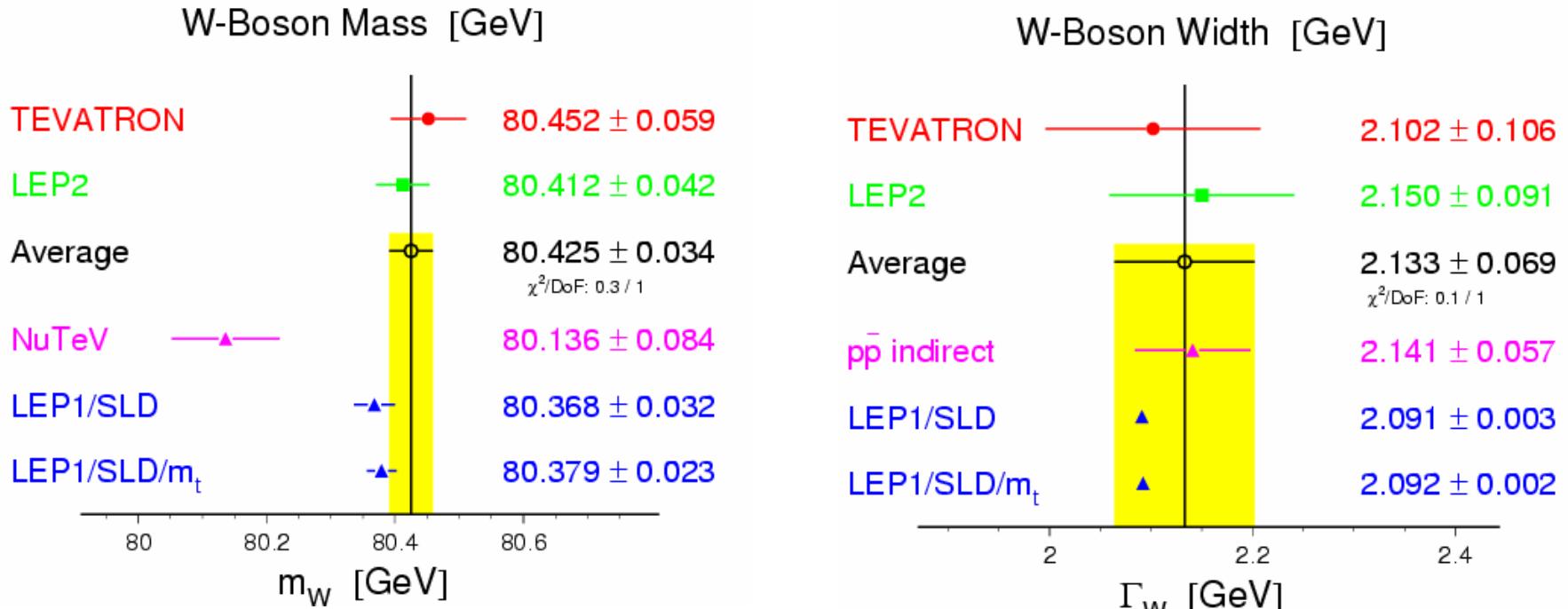
The long road to measuring \mathcal{M}_W



In Run 1, CDF used the Jacobian edge and high mass tail of the M_T distribution to extract M_W and Γ_W , respectively.



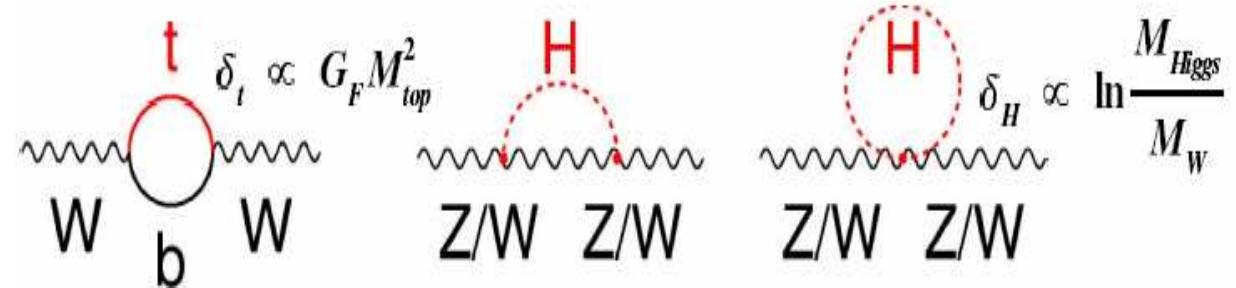
Final TeV Run I Results on \mathcal{M}_W , Γ_W



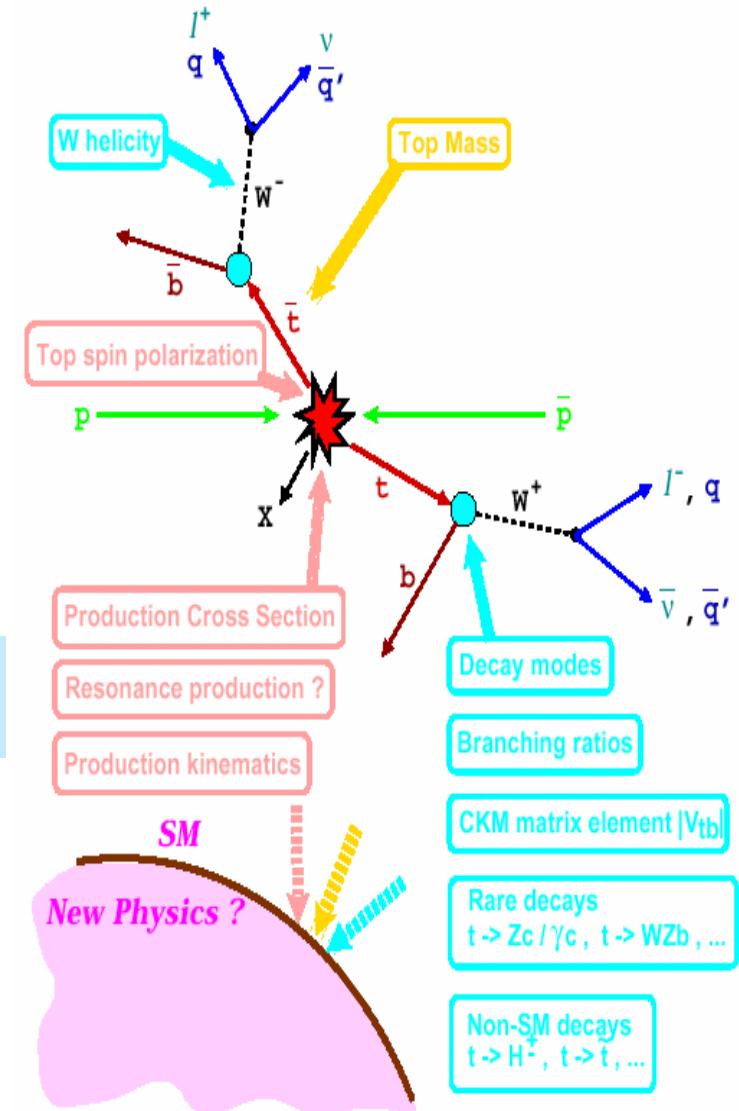
M_W, Γ_W consistent with SM

Run I CDF+D0 combined:
Final Run I hep-ex/0311039

First Run II results soon!



Top Physics Program





A Brief History of Top

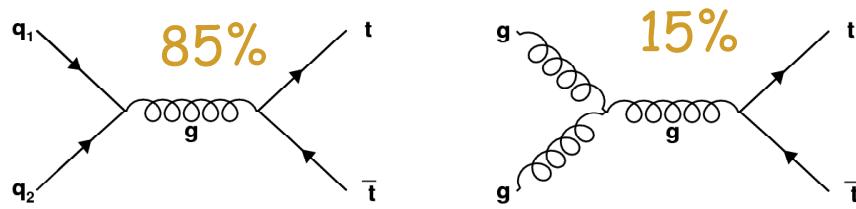


- ∅ Observed in 1995 in first $\sim 70 \text{ pb}^{-1}$ of Run 1 data.
- ∅ Final Run 1 top analyses based on $\sim 110 \text{ pb}^{-1}$.
 - ◆ Production cross sections in many channels.
 - ◆ Mass: $178.0 \pm 4.3 \text{ GeV}$ (CDF/DØ combined).
 - ◆ Event kinematics.
 - ◆ W helicity measurement.
 - ◆ Limits on single top production, rare/non-SM decays.
- ∅ Overall consistency with SM.
- ∅ But only ~ 100 analyzable top events → analyses statistics-limited.
- ∅ *Can only be studied at the Tevatron prior to LHC.*



Top Quark Production @ the Tevatron

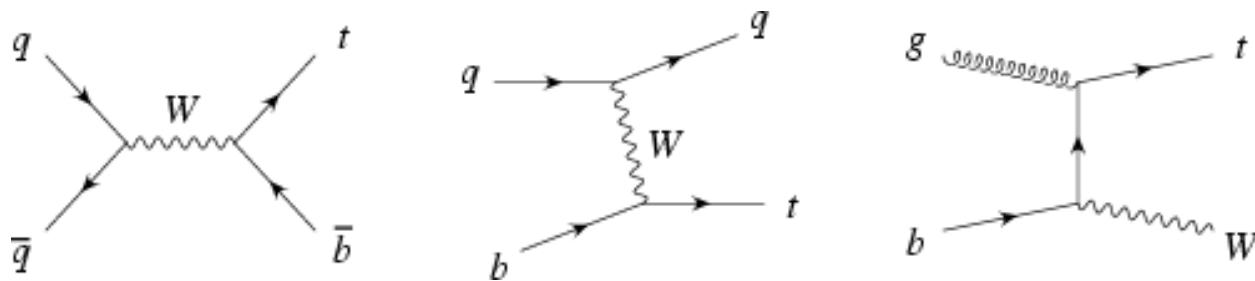
At the *Tevatron*, the top quark is produced strongly in pairs:



TeVatron s=1.96 TeV	m_t (GeV)	- PDF NLO σ(pb)	+PDF
	170	6.8	7.8
	175	5.8	6.7
	180	5.0	5.7

$$\sigma_{t\bar{t}}(\sqrt{s} = 1.96 \text{TeV}) \approx 1.30 \times \sigma_{t\bar{t}}(\sqrt{s} = 1.8 \text{TeV})$$

Or single top production via weak interaction:

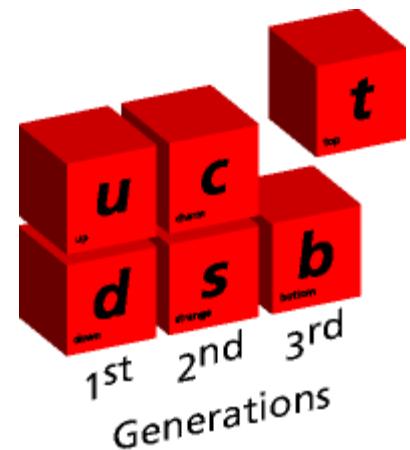


$$\sigma = 0.88 \pm 0.11 \text{ pb}$$

$$1.98 \pm 0.25 \text{ pb}$$

$$<0.1 \text{ pb}$$

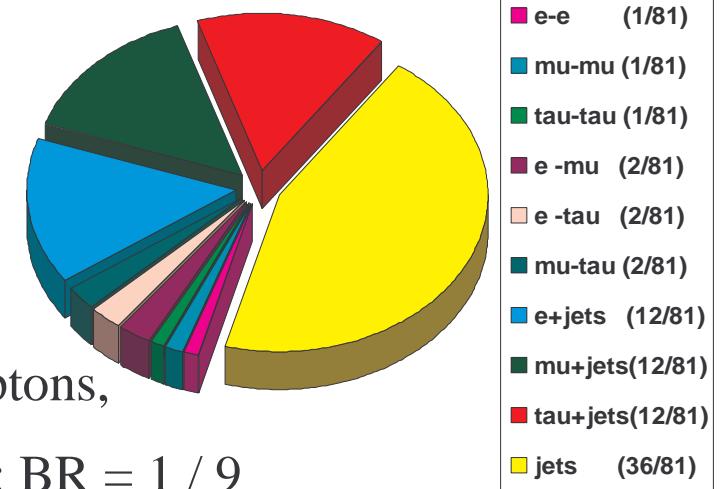
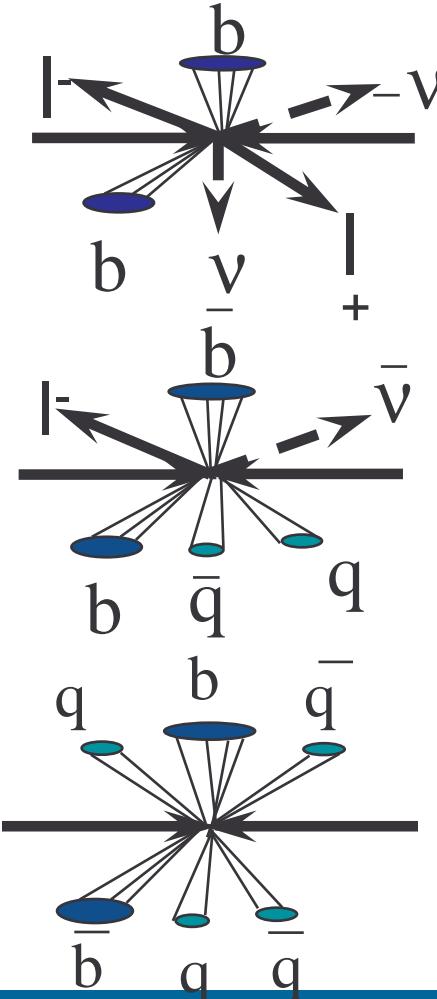
$$(\text{for } m_t 175 \text{ GeV})$$



$t\bar{t}$ Decay Modes

$\text{BR}(t \rightarrow W b) \sim 100\% \text{ in SM} \rightarrow$

3 main experimental signatures



Ø Dilepton (2 high- P_T leptons,
2 b jets, large missing E_T) : $\text{BR} = 1 / 9$

$$\text{BR}(ee, \mu\mu, e\mu) = 5\%$$

Ø Lepton + Jets (1 high- P_T lepton,
4 jets (2 b's), large missing E_T) : $\text{BR} = 4 / 9$

$$\text{BR}(e, \mu + \text{jets}) = 30\%$$

Ø All-hadronic (6 jets) : $\text{BR} = 4 / 9$

$$\text{BR}(\text{jets}) = 44\%$$

Top Dilepton Channel: $t\bar{t} \rightarrow l\nu l\nu b\bar{b}$

Two complementary analyses (197 pb^{-1}):

Ø DIL - Tight: (similar to Run 1)

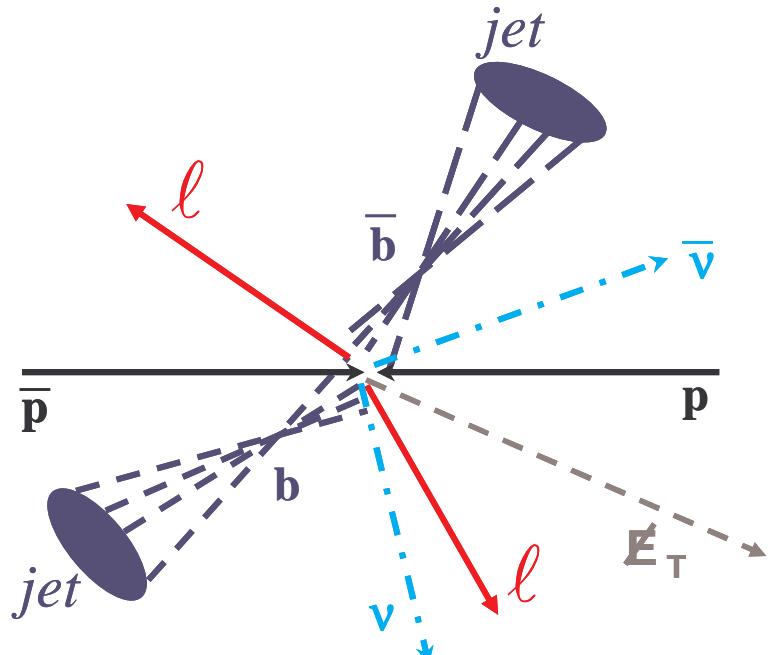
- ◆ Two high p_T e or μ with opposite charge, at least one isolated
 - ◆ At least two jets with large E_T
 - ◆ Large missing E_T
 - ◆ *Large total E_T in the event, H_T*
- **13 candidates with S/B ~ 4:1**

Ø LTRK- Loose: (sensitive to hadronic and leptonic τ decays)

- ◆ One high p_T central isolated e or μ plus an isolated high p_T track
 - ◆ At least two jets with large E_T
 - ◆ Large missing E_T
- **19 candidates with S/B ~ 2:1**

Phys. Rev. Lett. 93, 142001 (2004)

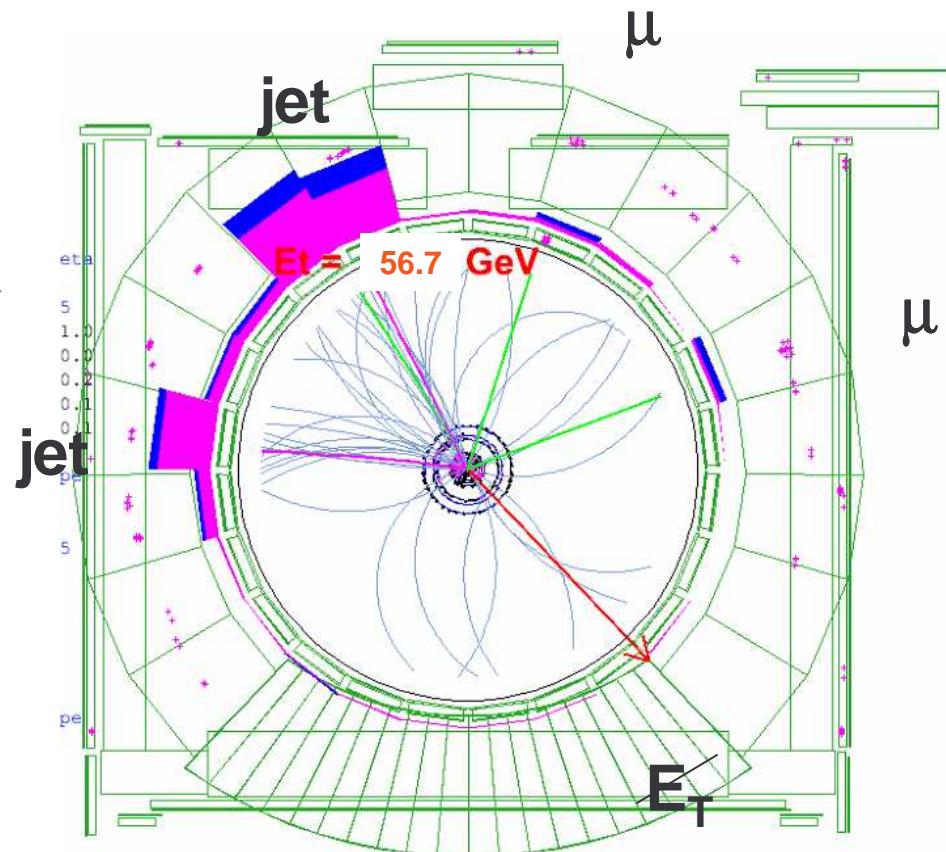
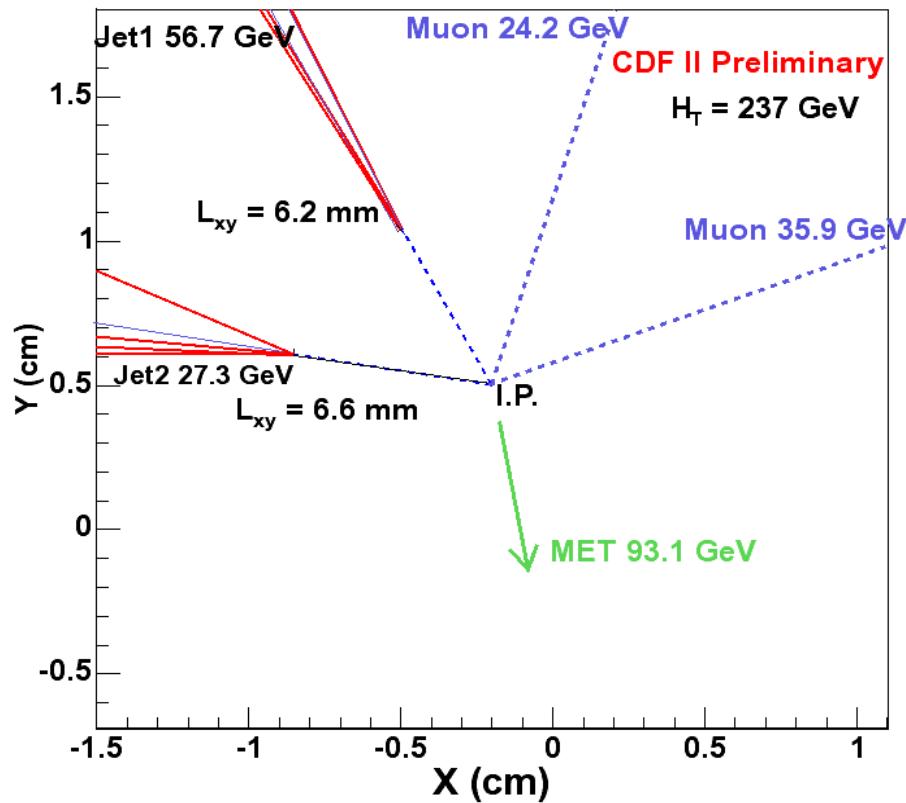
In today's talk: DIL



b tagging will come with more statistics.



Top Dilepton Candidate Event





Top Dilepton Backgrounds



Two main categories

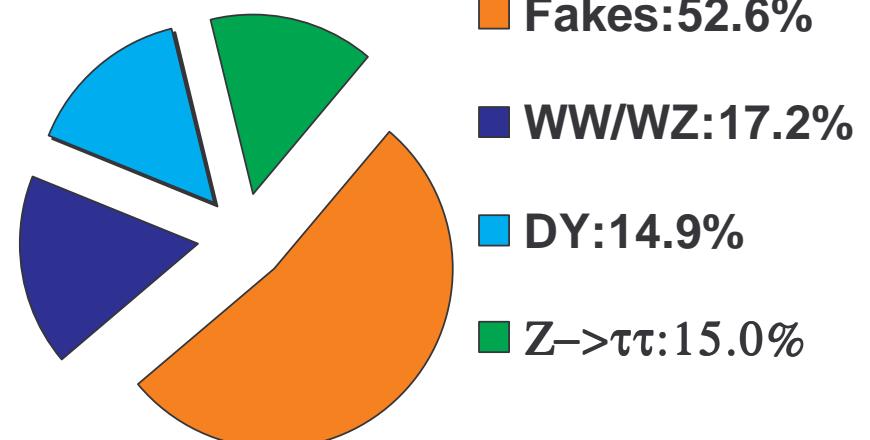
\emptyset Physical (Irreducible)

- ◆ dileptons with a real MET
 - Diboson Production:
 $WW/WZ/ZZ$
 - Di-tau :
 $\gamma^*/Z^0 \rightarrow \tau^+\tau^-$

\emptyset Instrumental

- ◆ dileptons with a “fake” MET or “misidentified” objects
 - Drell Yan:
 $\gamma^*/Z^0 \rightarrow e^+e^-$, $\gamma^*/Z^0 \rightarrow \mu^+\mu^-$
 - QCD Fakes:
 $W + \text{multijets}$, $b\bar{b}$

Background distribution





Acceptance and Systematics



$$\sigma(t\bar{t}) = \frac{N_{obs} - N_{bgnd}}{(\varepsilon \times A) \int L dt}$$

$\varepsilon x \mathcal{A}$ is efficiency of a dilepton event to pass all selection criteria:

$$\varepsilon x \mathcal{A} = (0.62 \pm 0.09) \%$$

Dominant uncertainties:

Jet Energy Scale

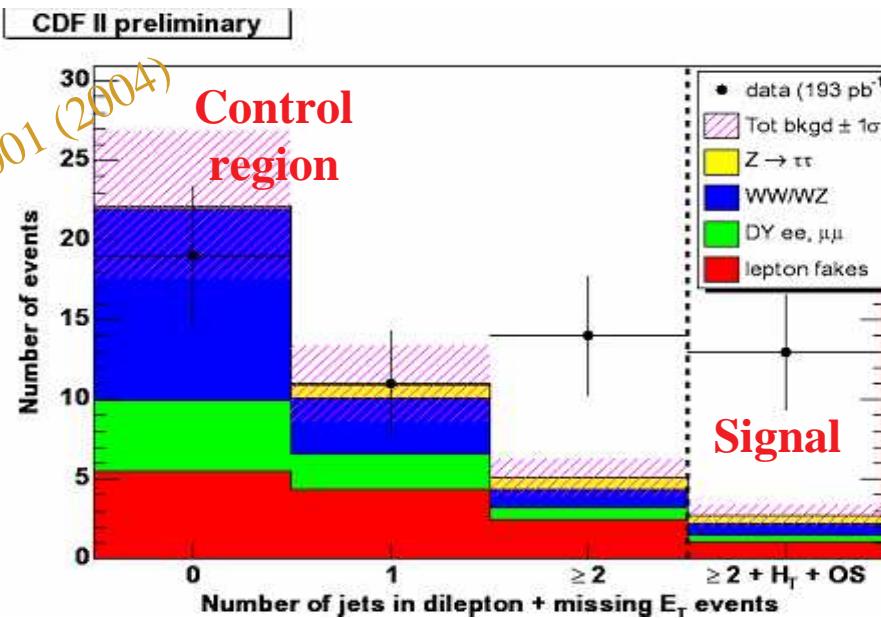
Lepton ID efficiencies

Background uncertainties have small effect on cross section uncertainty.

Signal and Background Uncertainties	DIL
Lepton(track) ID	5%
Jet energy scale - signal	5%
Jet energy scale - background	18–29%
Initial/final state radiation	2%
Parton distribution functions	6%
Monte Carlo Generators	6%
WW, WZ, ZZ estimate	20%
Drell-Yan Estimate	51%
Fake Estimate	41%

$\sigma_{t\bar{t}bar}$ Dilepton Channel: $t\bar{t}bar \rightarrow \ell\nu\ell\nu b\bar{b}$

Phys. Rev. Lett. 93, 142001 (2004)



$$\sigma(t\bar{t}) = 8.4^{+3.2}_{-2.7} (stat) ^{+1.5}_{-1.1} (syst) \pm 0.5 (lum) \text{ pb}$$

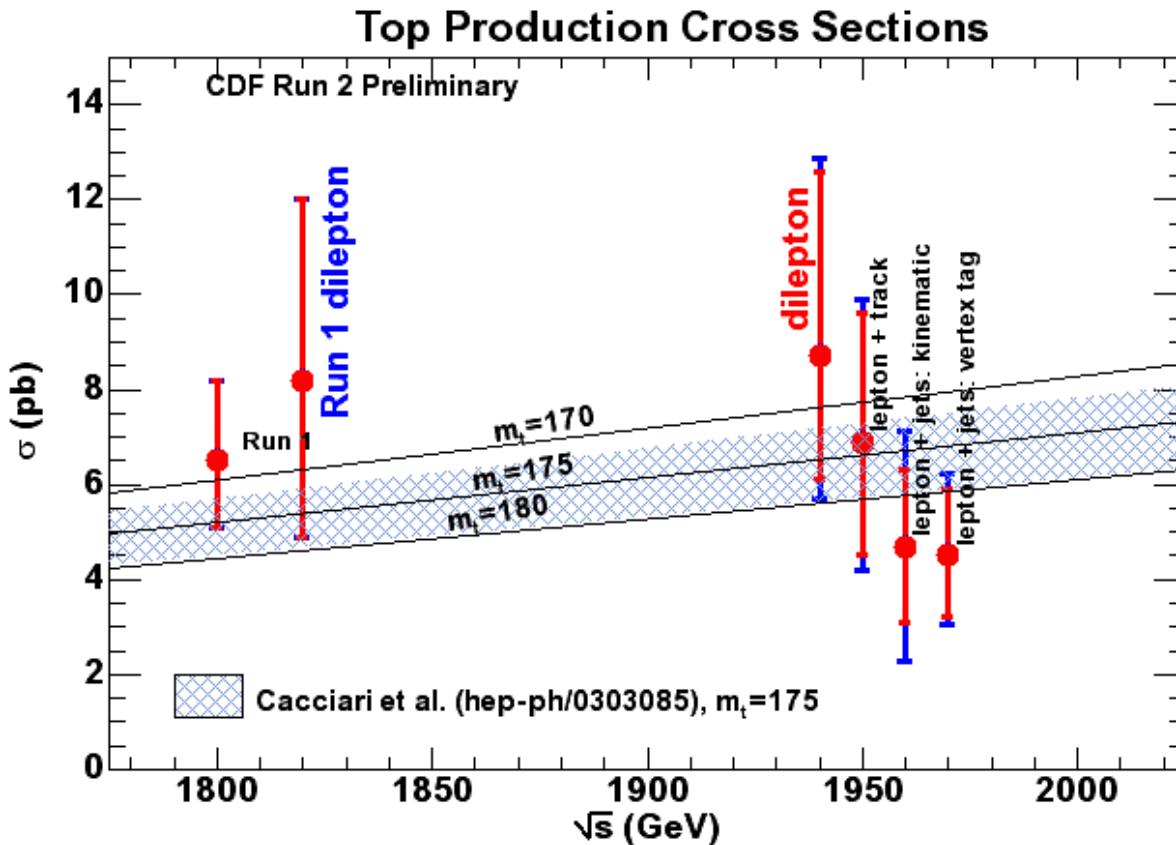
SM : $\sigma(t\bar{t}) = 6.7^{+0.7}_{-0.9} \text{ pb}$ At NLO @ $s=1.96 \text{ TeV}$ for $m_{top} = 175 \text{ GeV}$:
hep-ph/0303085 (Mangano et al)

Combining with LTRK analysis:

LTRK: $\sigma(t\bar{t}) = 7.0^{+2.7}_{-2.3} (stat) ^{+1.5}_{-1.3} (syst) \pm 0.4 (lum) \text{ pb}$

Comb: $\sigma(t\bar{t}) = 7.0^{+2.4}_{-2.1} (stat) ^{+1.6}_{-1.1} (syst) \pm 0.4 (lum) \text{ pb}$

12% reduced
statistical error



By measuring cross section using many different measurements:

- ∅ Test different assumptions
- ∅ Compare to look for new physics
- ∅ Combination ~20% precision
- ∅ Currently statistics-limited

NLO @ $\sqrt{s}=1.96$ TeV

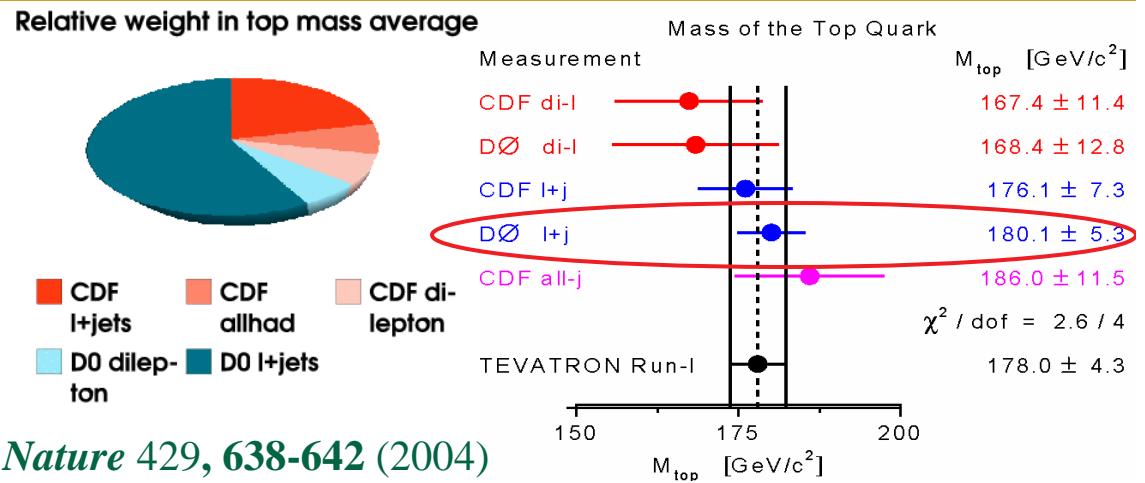
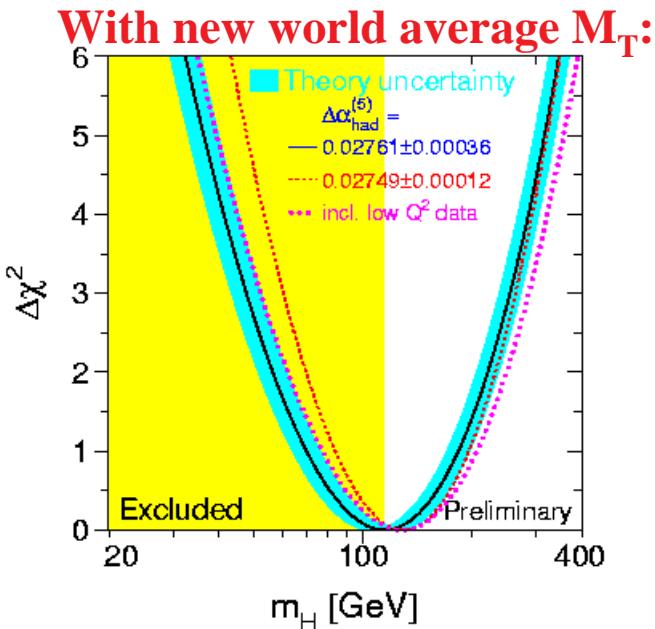
$M_{top} = 175$ GeV: $6.70^{+0.71}_{-0.88}$ pb

hep-ph/0303085 (ML Mangano et al)

New Top Mass World Average

New world average:
 $m_{top} = 178.0 \pm 4.3 \text{ GeV}/c^2$

Significant change of
 Higgs mass value
 favored by
 electroweak fits



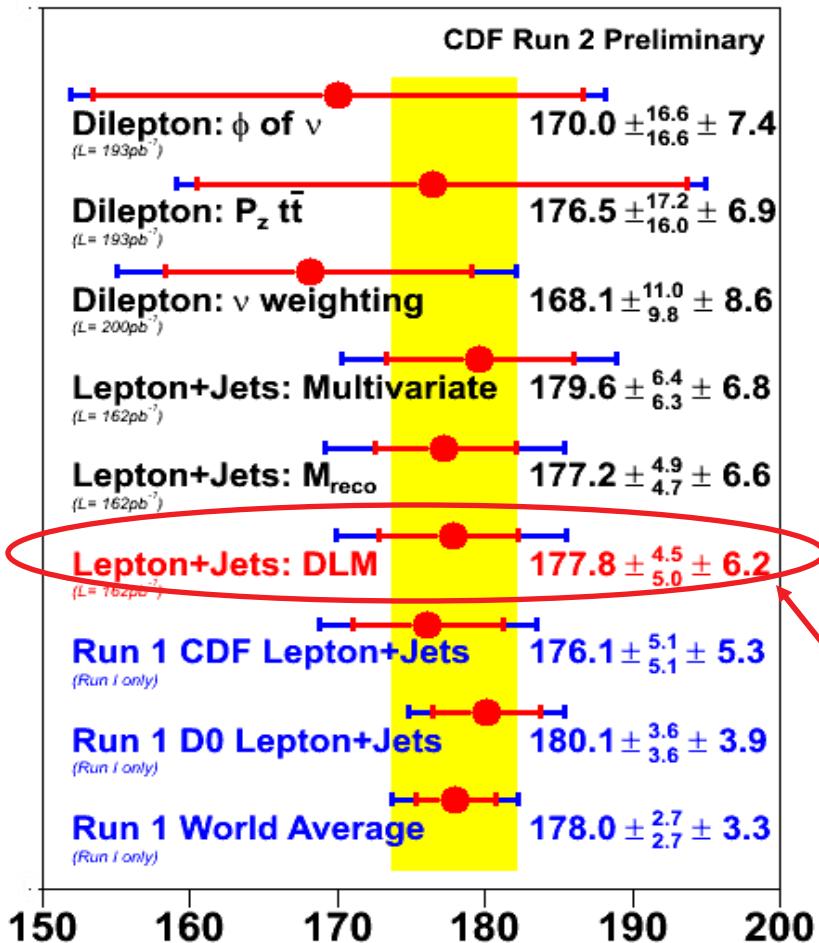
Old:

$m_{top} = 174.3 \pm 5.1 \text{ GeV}/c^2$
 $m_H = 96^{+69}_{-45} \text{ GeV}$
 $m_H < 219 \text{ GeV} @ 95\% \text{ C.L.}$

$\Delta m_{top} = 2\%$

$m_{top} = 178.0 \pm 4.3 \text{ GeV}/c^2$
 $m_H = 114^{+69}_{-45} \text{ GeV}$
 $m_H < 260 \text{ GeV} @ 95\% \text{ C.L.}$

$\% \Delta m_H = 16\%$



- ∅ Run II goal: m_{top} error < 3 GeV.
- ∅ Measure m_{top} in all experimental signatures using a variety of methods.
- ∅ Combine methods/channels
- ∅ Currently CDF is quoting the CDF Run II result as the one with the best *expected* error.

Methods are categorized as:

- ∅ Template
- ∅ Matrix Element weighting

DLM: K. Kondo J. Phys. Soc. 57 4126 (1988)

∅ Lepton + jets channel

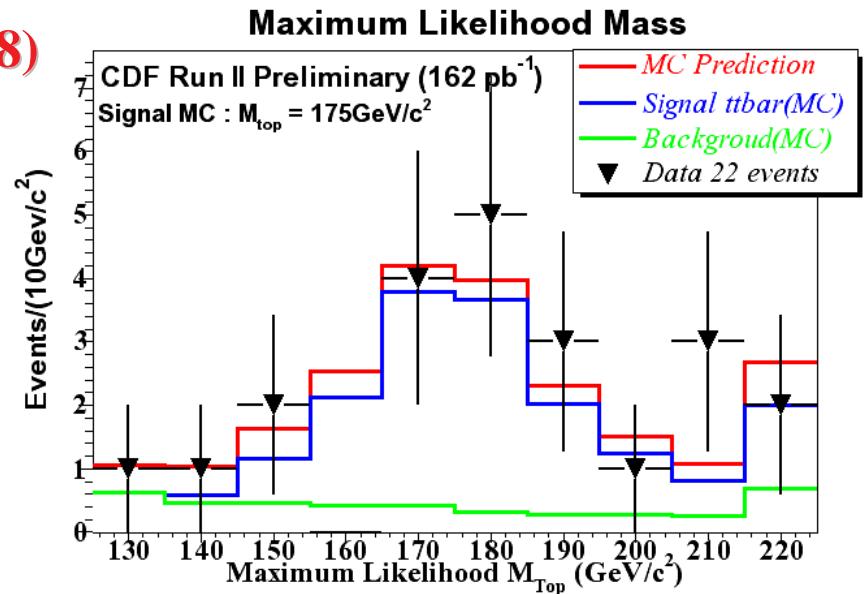
- ◆ 1 e, μ with $p_T > 20 \text{ GeV}/c$
 - ◆ Exactly 4 jets with $E_T > 15 \text{ GeV}$
 - ◆ Missing $E_T > 20 \text{ GeV}$
 - ◆ ≥ 1 b-tag
- 22 candidates, 4.2 ± 0.7 background

$$L^i(M_{top}) = \sum_{I_t} \sum_{I_s} \int \frac{2\pi^4}{Flux} F(z_a, z_b) f(p_T) |M|^2 w(I_t, x | y; M_{top}) dx$$

PDFs LO ttbar Matrix Element Transfer Function $w(x,y)$

Two summations over

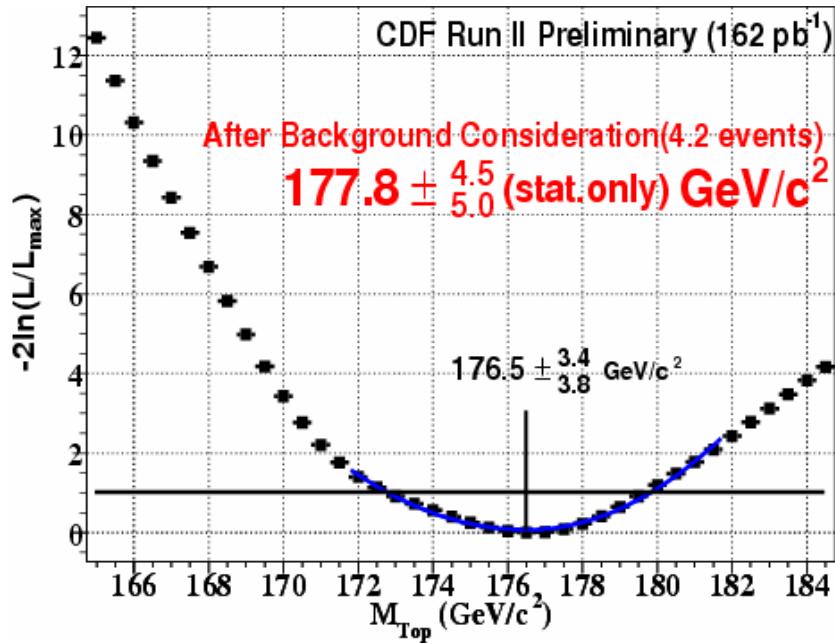
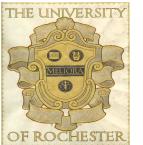
- ∅ Jet-Parton Assignments (I_t)
- ∅ Neutrino Solutions (I_s)



To obtain top mass, maximize $\prod_i L^{(i)}(M_{top})$



\mathcal{DLM} Top Mass Results



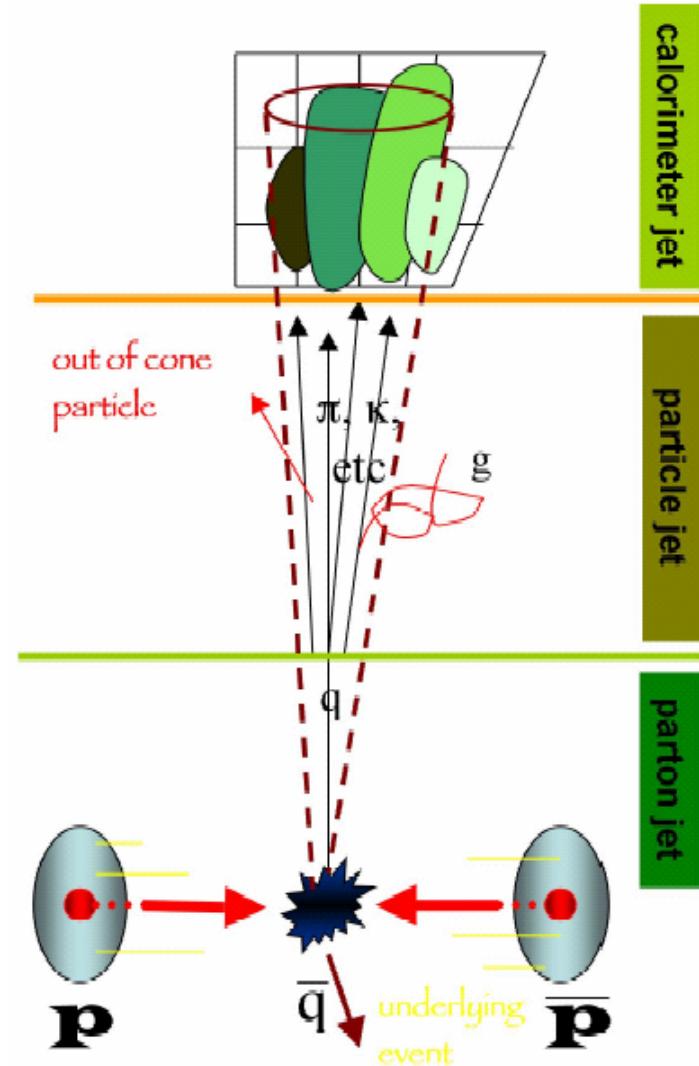
Top quark mass extracted after applying 19% background fraction mapping function (measured → true mass). Uncertainties also scale.

$$m_t = 177.8^{+4.5}_{-5.0} (\text{stat}) \pm 6.2 (\text{syst}) \text{ GeV}/c^2$$

Systematic Uncertainties	$\Delta M_{\text{top}}(\text{GeV}/c^2)$
Jet Energy Scale	5.3
Transfer function	2.0
ISR	0.5
FSR	0.5
PDF	2.0
Generator	0.6
Spin correlation	0.4
NLO effect	0.4
Bkg fraction	0.5
Bkg Modeling	0.5
MC Modeling	0.5
Total	6.2

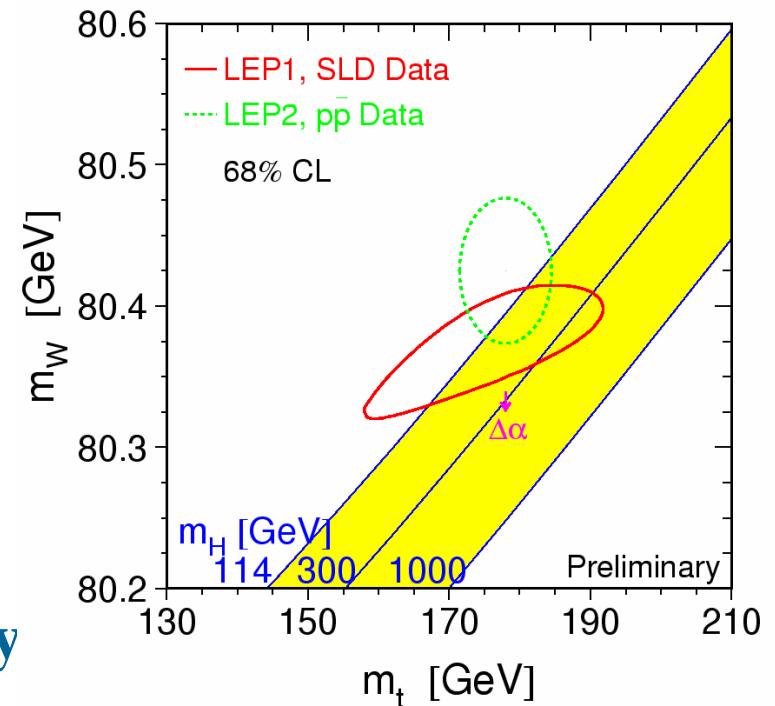
Jet Energy Scale

- ∅ Dominant systematic on current Tevatron top mass measurements. Will decrease soon as
 - ◆ Simulation improves
 - ◆ Get smarter with more statistics
- ∅ Absolute energy scale is the key!
 - ◆ No J/ ψ for jets
 - ◆ Mission impossible to trigger on $Z \rightarrow q\bar{q}$, though trying $Z \rightarrow b\bar{b}$
 - ◆ Must tune calorimeter simulation at single particle level!
 - ◆ Accurate inner detector material description important
 - ◆ Data control samples
 - $\gamma + \text{jet}$
 - $Z + \text{jet}$
 - di-jet
 - Hadronic W in top events!



SUMMARY

- Ø More W's and top than ever before!
- Ø We have reestablished some basic physics measurements and we have many new interesting physics results:
 - ◆ W/Z Cross Sections:
our standard candles
 - ◆ ttbar Cross Sections and top mass
- Ø It is the beginning of a program of precision physics at the Tevatron.
- Ø With this dataset and more on the way (4-9 fb^{-1} by 2009) precision measurements of m_t and m_W are in the near future, further constraining m_{Higgs} .



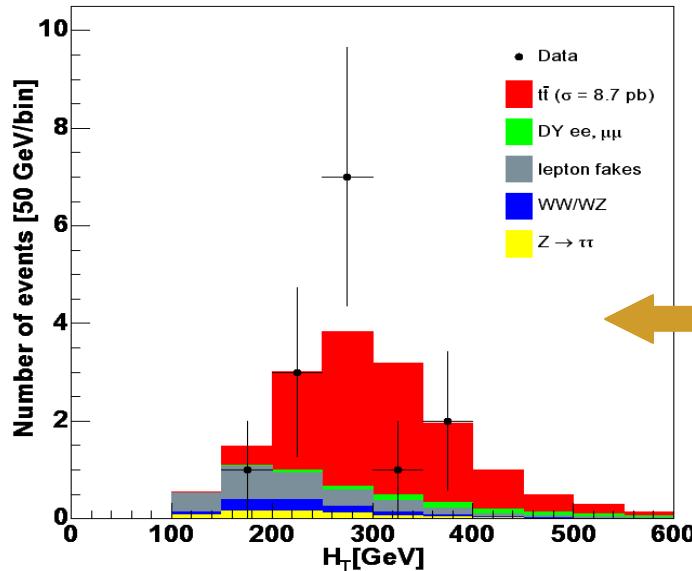
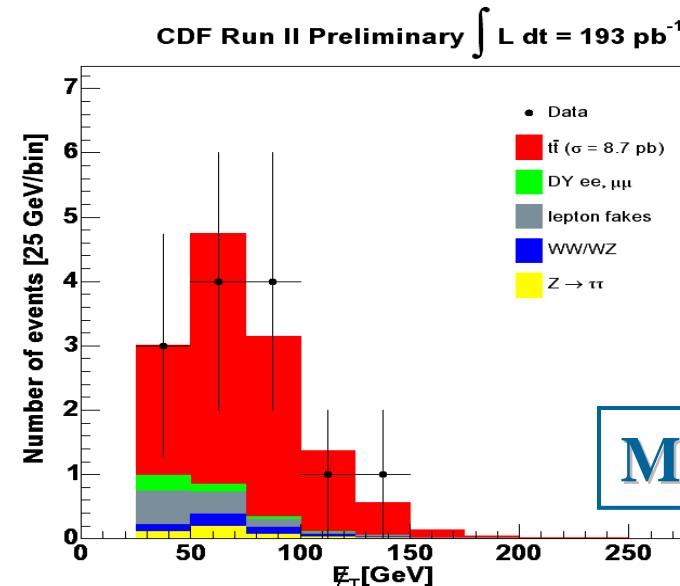


Backup Slides





Dilepton Kinematics

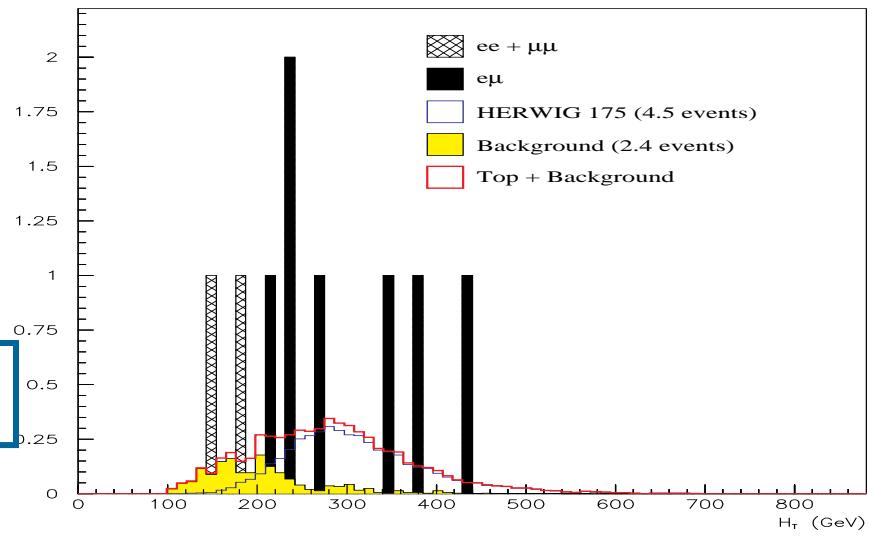
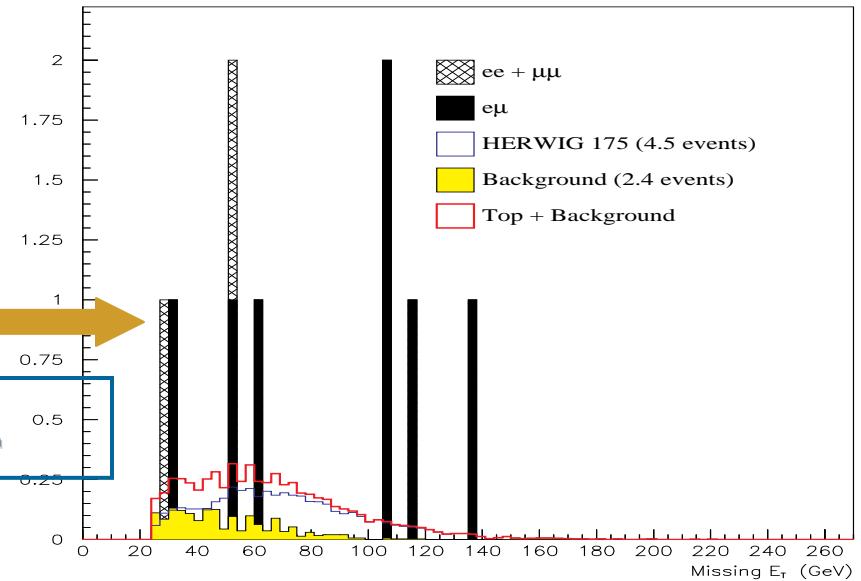


Run 1

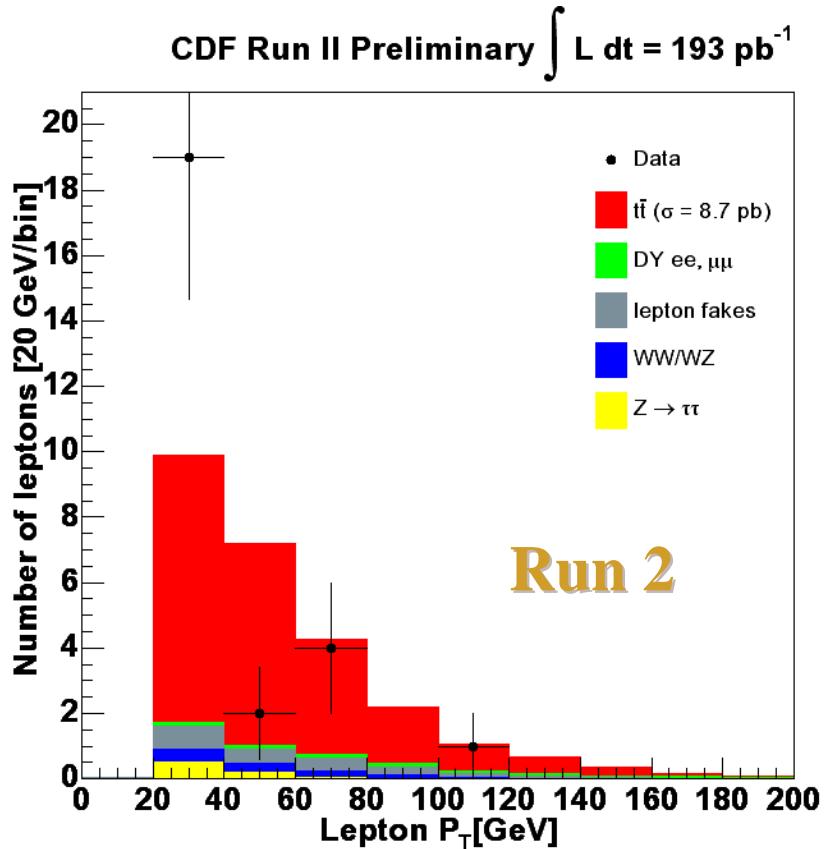
Missing E_T

Run 2

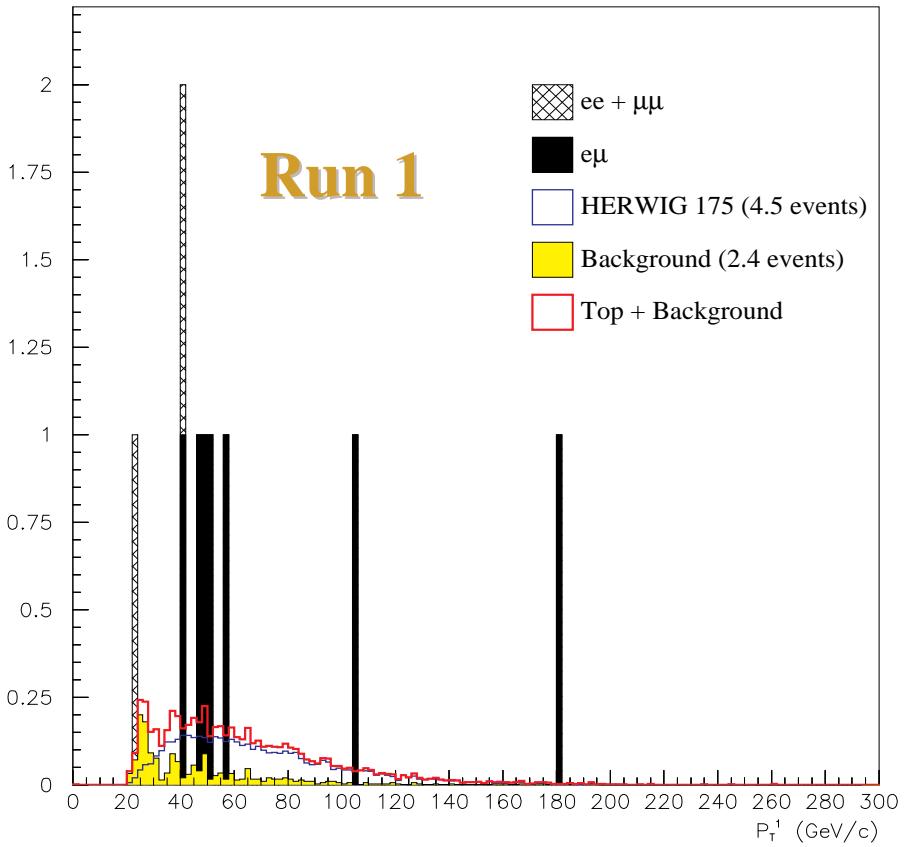
H_T



Dilepton Kinematics: Lepton p_T



Run 2 Lepton p_T softer than expected. Statistical fluctuation or a hint of something new?



Run 1: p_T of highest p_T lepton.

Run 2: p_T of both leptons
(double entry plot)